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SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

VOL. III.

1900.

Issued under the direction of—

THE INSTITUTION OF ELECTRICAL ENGINEERS.	THE PHYSICAL SOCIETY OF LONDON.

LONDON:
E. & F. N. SPON, LTD., 125, STRAND, W.C.

NEW YORK:
SPON & CHAMBERLAIN, 12, CORTLANDT STREET.

MELBOURNE, SYDNEY, ADELAIDE, BRISBANE:
GEORGE ROBERTSON & CO.

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ERRATA.

Abstract No. 22, last line : *for* change, *read* charge.
No. 58, last line : *for* glass, *read* platinum.
No. 136, line 6 from end : *for* κ/λ, *read* λ/κ.
No. 180, line 3 : *for* turning, *read* tuning.
No. 187, line 2 from end : *for* C. P. Mathews, *read* C. P. Matthews.
No. 274, line 1 : *for* J. Bose, *read* J. Buse.
No. 385, line 3 from end : *for* specific gravity capacity, *read* specific capacity.
No. 511, line 3 from end : *for* from 30° to 120°, *read* from 30° to − 120°.
No. 1050, line 3 : *for* (see 1900, Abstract No. 74), *read* (see 1900, Abstract No. 72).
No. 1225, line 2 : *for* pp. 68–80, *read* pp. 66–80.
No. 1229, line 1 : *for* E. Piérard, *read* J. Piérart.
No. 1229, line 2 from end : *for* T. Piérart *read* The author in reply.
No. 1481, line 9 : *for* at right action, *read* at right angles.
No. 1580, line 7 : *for* William, *read* Willans.
No. 1587, p. 601, line 2 : *for* trucks, *read* tracks.
No. 1679, line 2 : *for* Roy. Dublin Soc., Proc., *read* Roy. Dublin Soc., Trans.
No. 1817, line 1 : *for* Z. Gyözö, *read* Gyözö Zemplén.
No. 1979, line 1 : *for* Double Films, *read* Durable Films.
No. 1988, line 2 : *for* pp. 257–258, *read* pp. 251–258.
No. 2064, line 2 : *for* pp. 62–68, *read* pp. 62–79.
No. 2368, line 1 : *for* G. F. Walker, *read* S. F. Walker.

Erratum in Vol. II.

Abstract No. 1795, line 2 : *for* pp. 5–58, 1899. Discussion, pp. 59–80, *read* pp. 121–174, 1898. Discussion, pp. 175–205.

NOTE.—In the case of the Transactions of the American Institute of Electrical Engineers, the page numbers in the Abstracts refer to the monthly parts, and are therefore liable to be incorrect for the yearly volumes.

LIST OF JOURNALS.

In 1900 Abstracts were made from the following Journals. An asterisk (*) indicates that Abstracts were only occasionally made from those so marked.

Abbreviations.	Full Title.	Price.	Publishers, or Agents.
Acad. Sci. Cracovie, Bull.	Bulletin de l'Académie des Sciences de Cracovie	Single copy, 90 centimes; 8 francs per annum	Librairie de la Société anonyme polonaise. Cracovie
Acad. Sci. St. Pétersbourg, Bull.	Bulletin de l'Académie Impériale des Sciences de St. Pétersbourg	Single copy, 2 marks 50 pfennigs	Published by the Academy
Acad. Sci. St. Pétersbourg, Mém.	Mémoires de l'Académie Impériale des Sciences de St. Pétersbourg	Single copy, 3 marks	Published by the Academy
Accad. Lincei, Atti	Atti della R. Accademia dei Lincei, Roma	—	Published by the Academy
Accad. Sci. Torino, Atti	Atti della R. Accademia delle Scienze di Torino	—	Published by the Academy
Akad. Wiss. Wien, Sitzb.	Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften, Wien	Single copies, 2s. 4d. to 7s. 6d.	Carl Gerold's Sohn, Barbaragasse 2, Vienna
Amer. Acad., Mem.	Memoirs of the American Academy of Arts and Sciences	—	American Academy of Arts and Sciences, 101–2, Beacon Street, Boston.
Amer. Acad., Proc.	Proceedings of the American Academy of Arts and Sciences	—	Published by the Academy (as above)
Amer. Assoc., Proc.	Proceedings of the American Association for the Advancement of Science	—	Amer. Assoc. for the Advancement of Science, Salem, Mass., U.S.A.
Amer. Electn.	American Electrician	Single copy, 10 cents; $1 per annum	120, Liberty Street, New York.
Amer. Inst. Elect. Engin., Trans.	Transactions of the American Institute of Electrical Engineers	Single copy, 50 cents; $5 per annum	Published by the Institute, 26, Cortlandt Street, New York
Amer. Journ. Sci.	American Journal of Science	$6.40 per ann., post free	Tuttle, Morehouse & Taylor, 125, Temple Street, New Haven, Connecticut, U.S.A.
Amer. St. Rly. Assoc.	Report of the American Street Railway Association	—	2020 State Street, Chicago
Ann. d. Physik	Annalen der Physik	38 marks per annum	J. A. Barth, Rossplatz 17, Leipzig
[illegible]	Annales de Chimie et de Physique	36 francs per annum	Gauthier-Villars, Quai des Grands-Augus- [illegible]

ABBREVIATIONS	FULL TITLE	PRICE	PUBLISHERS, OR AGENTS
Archiv Math. Phys.	Archiv der Mathematik und Physik	—	C. A. Koch's Verlagsbuchhandlung, Leipzig
Archiv Post,Tele.	Archiv für Post und Telegraphie	—	Published by the Reichs-Postamt, Berlin
Archives d'El. Médicale	Archives d'Electricité Médicale	22 francs per annum	O. Doin, Place de l'Odéon 8, Paris
Archives Néerlandaises	Archives Néerlandaises des Sciences Exactes et Naturelles	6 fl. per volume	Martinus Nijhoff, La Haye, Holland
Archives des Sciences	Archives des Sciences Physiques et Naturelles, Genève	Single copy, 2.50 francs; 25 francs per annum	Bureau des Archives, 18 Pélisserie, Geneva
Assoc. Ing. Él. Liège, Bull.	Bulletin de l'Association des Ingénieurs-Electriciens, Liège	20 francs per annum	Gauthier-Villars, Quai des Grands Augustins 55, Paris
Assoc. Suisse Élect., Ann.	Annuaire de l'Association Suisse des Électriciens, Neuchâtel	—	J. Bollmann, Zurich, Switzerland
Astrophys. Journ.	Astrophysical Journal	Single copy, 50 cents; 18s. per annum	The University of Chicago Press, Chicago, and W. Wesley & Son, 28, Essex Street, Strand, W.C.
Automotor Journ.	Automotor and Horseless Vehicle Journal	Single copy, 6d.; 7s. per annum	F. King & Co., Ltd., 62, St. Martin's Lane, London, W.C.
*Ber.	Berichte der Deutschen Chemischen Gesellschaft	—	—
Bureau des Longitudes, Ann.	Annuaire publié par le Bureau des Longitudes	1 franc 50 centimes	Gauthier-Villars, Quai des Grands Augustins 55, Paris
*Calcutta Univ. Mag.	Calcutta University Magazine	Single copy, 3 annas	I. C. Bose & Co., Stanhope Press, 249, Bow-Bazar Street, Calcutta
Cambridge Phil. Soc., Proc.	Proceedings of the Cambridge Philosophical Society	Single copy, 2s. 6d.	C. J. Clay & Sons, Ave Maria Lane, E.C.
Cambridge Phil. Soc., Trans.	Transactions of the Cambridge Philosophical Society	Single copy, 7s. 6d.	C. J. Clay & Sons, Ave Maria Lane, E.C.
Canad. Elect. News	Canadian Electrical News	Single copy, 10 cents; $1 per annum	C. H. Mortimer Publishing Co., Ltd., Confederation Life Buildings, Toronto, Canada
Canad. Inst., Proc.	Proceedings of the Canadian Institute	—	Arbuthnot Bros. & Co., Lombard Street, Toronto, Canada
Cassier	Cassier's Magazine	Single copy, 1s.; 12s. per annum, post free	33, Bedford Street, Strand, W.C.
Centralblatt Accumulatoren- und Elementenk.	Centralblatt für Accumulatoren- und Elementenkunde	3 marks 50 pf. per quarter	W. Knapp, Halle a. S., Germany

LIST OF JOURNALS—*continued.*

ABBREVIATIONS.	FULL TITLE.	PRICE.	PUBLISHERS, OR AGENTS.
Chem. News	Chemical News and Journal of Science	Single copy, 4½d. post free	E. J. Davey, 6 & 7, Creed Lane, Ludgate Hill, E.C.
Chem. Soc., Journ.	Journal of the Chemical Society	—	Gurney & Jackson, 1, Paternoster Row, E.C.
Chem. Soc., Proc.	Proceedings of the Chemical Society	—	Gurney & Jackson, 1, Paternoster Row, E.C.
Comptes Rendus	Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences	34 francs per annum	Gauthier-Villars, Quai des Grands Augustins 55, Paris
Deutsch. Phys. Gesell., Verh.	Verhandlungen der Deutschen Physikalischen Gesellschaft	4 marks per annum	—
Deutsche Zeitschr. Elektrotechn.	Deutsche Zeitschrift für Elektrotechnik. (No longer published.)	2 marks quarterly	W. Knapp, Halle a. S., Germany
Écl. Électr.	L'Éclairage Électrique	60 fr. per ann., post free	G. Carré & C. Naud, 3, Rue Racine, Paris
Elect. Engin.	Electrical Engineer	Single copy, 3d.; 13s. per annum, post free	139 & 140, Salisbury Court, Fleet Street, E.C.
Elect. Rev.	Electrical Review (London)	Single copy, 4d.; 19s. 6d. per annum, post free	Alabaster, Gatehouse & Co., 4, Ludgate Hill, E.C.
Elect. Rev. N.Y.	Electrical Review (New York)	Single copy, 10 cents; $5 per annum	Times Buildings, 41, Park Row, New York, & H. W. Hall, 42, Old Broad St., London, E.C.
Elect. World and Engineer	Electrical World and Engineer	Single copy, 10 cents; $6 per annum	120, Liberty Street, New York, & Hastings House, Norfolk Street, Strand, London
Electrician	The Electrician	Single copy, 6d.; 26s. per annum	Salisbury Court, Fleet Street, E.C.
Électricien	L'Électricien	Single copy, 50 centimes; 25 francs per annum	L. de Soye et Fils, Rue des Fossés-St.-Jacques 18, Paris
Electricity, N.Y.	Electricity (New York)	Single copy, 10 cents; $4.50 per annum	136, Liberty Street, New York
Elekt. Runds.	Elektrotechnische Rundschau	12 marks per annum	10, Kaiserstrasse, Frankfurt a. M., Germany
Elektrochem. Zeitschr.	Elektrochemische Zeitschrift	18 marks 40 pfg. per ann.	M. Krayn, 86, Steglitzerstrasse, Berlin, W.
Elektrotechn. Zeitschr.	Elektrotechnische Zeitschrift	25s. per annum	J. Springer, 24, Monbijouplatz 3, Berlin
Elettricità, Milan	L'Elettricità (Milan)	Single copy, 25 centesimi; 18 lire per annum	Via Cusani 11, Milano, Italy
Engineer	The Engineer (London)	Single copy, 6½d. post free; £1 9s. per ann., post free	33, Norfolk Street, Strand, W.C.
Engineering	Engineering	Single copy, 6½d. post free; £1 9s. 2d. per annum, post free	35 & 36, Bedford Street, Strand, W.C.

Abbreviations.	Full Title.	Price.	Publishers, or Agents.
Eng. Club, Phil., Proc.	Proceedings of the Engineers' Club of Philadelphia	$2 per volume	1122, Girard Street, Philadelphia
Eng. Mag.	The Engineering Magazine	Single copy, 1s.; 12s. 6d. per annum, post free	222–225, Strand, London, W.C.
Eng. News	Engineering News	Single copy, 15 cents; $6.31 per annum	220, Broadway, New York, and Effingham House, 1, Arundel Street, Strand, London
Feilden	Feilden's Magazine	Single copy, 1s.; 12s. 6d. per annum, post free	Temple Chambers, Embankment, London, E.C.
Frank. Inst., Journ.	Journal of the Franklin Institute	Single copy, 50 cents; $5 per annum	Franklin Institute, Philadelphia
Génie Civil	Génie Civil	Single copy, 1 franc; 45 francs per annum	Rue de la Chaussée d'Antin 6, Paris
Gesell. Wiss. Göttingen, Nachr. Math.-Phys. Klasse	Nachrichten der Gesellschaft der Wissenschaften zu Göttingen, Mathematisch-physikalische Klasse	—	Lüder Horstmann, Göttingen, Germany
Horseless Age	The Horseless Age	Single copy, 10 cents; $4 per annum	E. P. Ingersoll, 150, Nassau St., New York
Ind. Élect.	L'Industrie Électrique	Single copy, 1 franc; 26 francs per annum	A. Lahure, 9, Rue de Fleurus, Paris
Ind. Électrochim.	L'Industrie Électrochimique	Single copy, 60 centimes; 8 francs per annum	H. Becker, 5, Rue Guy-Patin, Paris
Indus. and Iron	Industries and Iron. (No longer published.)	Single copy, 4½d. post free	39 & 40, Shoe Lane, E.C.
Inst. Civ. Engin., Proc.	Proceedings of the Institution of Civil Engineers	—	Published by the Institution, Great George Street, London, S.W.
Inst. Elect. Engin., Journ.	Journal of the Institution of Electrical Engineers	Single copy varies from 1s. 6d. to 7s. 6d.	E. & F. N. Spon, 125, Strand, London, W.C.
Inst. Engin. and Shipbuilders, Trans.	Transactions of the Institution of Engineers and Shipbuilders in Scotland	—	Published by the Institution, 207, Bath Street, Glasgow
Inst. Mech. Engin., Proc.	Proceedings of the Institution of Mechanical Engineers	—	Published by the Institution, Storey's Gate, St. James's Park, London, S.W.
Journal of Electricity, S. F.	Journal of Electricity, Power, and Gas (San Francisco)	Single copy, 10 cents ...	315, Cherry Street, San Francisco, Cal., U.S.A.
urn. Phys. Chem.	Journal of Physical Chemistry	$4 per annum	Published at Cornell University
n. de Physique	Journal de Physique	15 fr. per ann., post free	11, Rue Rataud, Paris

LIST OF JOURNALS—*continued.*

ABBREVIATIONS.	FULL TITLE.	PRICE.	PUBLISHERS, OR AGENTS.
Journ. Télégraph.	Journal Télégraphique	Single copy, 50 centimes; 5 francs per annum	Berne, Switzerland
Light Rly. and Tramway Journ.	Light Railway and Tramway Journal	Single copy, 1s.; 10s. per annum	16, Eldon Street, London, E.C.
Lightning	Lightning	Single copy, 2d.; 10s. 6d. per annum	8, Bream's Buildings, Chancery Lane, W.C.
Locomotion Automobile	La Locomotion Automobile	Single copy, 5 centimes; 20 francs per annum	Place de la Madeleine, Rue Chauveau-Lagarde 4, Paris
Manchester Lit. and Phil. Soc., Mem.	Memoirs of the Manchester Literary and Philosophical Society	Single copy, 2s.	36, George Street, Manchester
Mech. Eng.	The Mechanical Engineer	Single copy, 6d.; 20s. per annum, post free	53, New Bailey Street, Manchester
Monthly Weather Rev.	The Monthly Weather Review	Single copy, 10 cents ...	Published by the U.S. Weather Bureau, Washington
N. Cimento	Nuovo Cimento (Pisa)	18 lire per annum	P. Salvioni, Tipografia Pieraccini, Via de Monte 12, Pisa
Nature	Nature	Single copy, 6d.	Macmillan & Co., Ltd., St. Martin's Street, London, W.C.
Nova Scotian Inst., Trans.	Transactions of the Nova Scotian Institute of Science	——	Published by the Institute, Halifax, Nova Scotia
Phil. Mag.	London, Edinburgh, & Dublin Philosophical Magazine	2s. 6d. per month, occasionally 5s.	Taylor & Francis, Red Lion Court, Fleet Street, E.C.
Phys. Rev.	Physical Review	Single copy, 50 cents; $4 per annum	Macmillan & Co., Ltd., London and New York
Phys. Soc., Proc.	Proceedings of the Physical Society of London	——	Taylor & Francis, Red Lion Court, Fleet Street, E.C.
Phys. Zeitschr.	Physikalische Zeitschrift	5 Mk. per quarter, or 25 Mk. per ann., post free	S. Hirzel, Königstrasse 2, Leipzig
Preuss. Akad. Wiss. Berlin, Sitzb.	Sitzungsberichte der Preussischen Akademie der Wissenschaften zu Berlin	12 marks per annum	Königliche Akademie der Wissenschaften, Berlin
Railroad Gazette	Railroad Gazette	$6.08 per ann., post free	32, Park Place, New York
Revue de l'El, Berne	Revue de L'Électricité, Berne	8 francs per annum	Place de l'Ours 29, Berne
Revue Int. d'Electrothérapie	Revue Internationale d'Électrothérapie et	Single copy, 50 centimes;	3, Place du Théatre Français, Paris

Abbreviations.	Full Title.	Price.	Publishers, or Agents.
Revue Scientif.	Revue Scientifique	Single copy, 60 centimes; 35 francs per annum	19, Rue des Saints Pères, Paris, and T. F. Unwin, 11, Paternoster Square, E.C.
Rivista Sci.-Industriale	Rivista Scientifico-Industriale	12 lire per annum	2, Lungarno della Zecca, Firenze, Italy
*Roy. Astro. Soc., Monthly Notices	Monthly Notices of the Royal Astronomical Society	—	—
Roy. Dublin Soc., Proc.	Scientific Proceedings of the Royal Dublin Society	Single copy, 6d.	Published by the Society, Leinster House, Dublin
Roy. Dublin Soc., Trans.	Transactions of the Royal Dublin Society	—	Published by the Society, Leinster House, Dublin
Roy. Inst., Proc.	Proceedings of the Royal Institution of Great Britain	—	Published by the Institution, 21, Albemarle Street, W.
Roy. Soc. Canada, Proc.	Proceedings of the Royal Society of Canada	—	—
Roy. Soc. N. S. Wales, Journ. and Proc.	Journal and Proceedings of the Royal Society of New South Wales	—	5, Elizabeth Street, Sydney, New South Wales
Roy. Soc., Phil. Trans.	Philosophical Transactions of the Royal Society of London	Varies for separate papers, from 1s.	Dulau & Co., 37, Soho Square, London, W.
Roy. Soc., Proc.	Proceedings of the Royal Society of London	Varies for separate parts, from 1s. 6d.	Dulau & Co., 37, Soho Square, London, W.
Roy. Soc. Queensland, Proc.	Proceedings of the Royal Society of Queensland	—	Pole & Co., 95, Elizabeth Street, Brisbane
Schweizerische Blätter für Elektrotechnik	Schweizerische Blätter für Elektrotechnik, Berne	8 francs per annum	Place de l'Ours 29, Berne
Science	Science	Single copy, 15 cents	Macmillan & Co., 66, Fifth Avenue, New York
Scientific American	Scientific American	Single copy, 8 cents; 16s. 5d. per annum, post free	361, Broadway, New York
Scientific Australian	Scientific Australian	2s. 6d. per annum, post free	Turner & Henderson, 16–18, Hunter Street, Adelaide
Soc. Arts Journ.	Journal of the Society of Arts	Single copy, 6d.	G. Bell & Sons, York St., Covent Garden, W.C.
Soc. Belge Élect., Bull.	Bulletin de la Société Belge d'Électriciens	Single copy, 2 francs; 20 frs. per ann., post free	54, Rue Froissart, Brussels
Soc. Chem. Ind., Journ.	Journal of the Society of Chemical Industry	30s. per annum	Published by the Society, 9, Bridge Street, Westminster, S.W.
Franç. Phys., Bull	Bulletin de la Société Française de Physique	—	Published by the Society 44, Rue de Rennes, Paris
Franç. Phys., Séances	Séances de la Société Française de Physique	—	Published by the Society (as above)

LIST OF JOURNALS—*continued.*

Abbreviations.	Full Title.	Price.	Publishers, or Agents.
Soc. Imp. Nat. Moscou, Bull.	Bulletin de la Société Impériale des Naturalistes de Moscou	—	J. N. Kouchnereff & Co., Pimenowskaia, Moscou
Soc. Int. Élect.. Bull.	Bulletin de la Société Internationale des Electriciens	Single copy, 2.50 francs; 27 francs per annum	Gauthier - Villars, Quai des Grands-Augustins 55, Paris
Street Rly. Journ.	Street Railway Journal	Single copy, 50 cents; $6 per annum, post free	A. C. Shaw, Hastings House, Norfolk Street, Strand, W.C.
Street Rly. Rev.	Street Railway Review	Single copy, 30 cents; $4 per annum	Windsor and Kenfield Publishing Co., Monon Building, Chicago
Tech. Versuch. Berlin, Mitth.	Mittheilungen der Technischen Versuchanstalten zu Berlin	12 marks per annum	J. Springer, 24, Monbijouplatz 3, Berlin
Tram. Rly. World	Tramway and Railway World	Single copy, 1s. post free	Amberley House, Norfolk Street, W.C.
U.S. Weather Bureau, Bull.	Bulletin of the United States Weather Bureau	—	Published by the U.S. Weather Bureau, Washington
West. Electn.	Western Electrican (Chicago)	Single copy, 10 cents; $3 per annum	510, Marquette Buildings, Chicago, and 44, Fleet Street, London, E.C.
Zeitschr. Elektrochem.	Zeitschrift für Elektrochemie	4 marks per quarter	W. Knapp, Halle a. S., Germany
Zeitschr. Elektrotechn., Wien	Zeitschrift für Elektrotechnik (Wien)	30 fr. per ann., post free	Nibelungengasse 7, Vienna
Zeitschr. Instrumentenk.	Zeitschrift für Instrumentenkunde		
Zeitschr. Instrumentenk., Beib.	Beiblatt zur Zeitschrift für Instrumentenkunde	20 marks per annum	J. Springer, 24, Monbijouplatz 3, Berlin
Zeitschr. Phys. Chem.	Zeitschrift für Physikalische Chemie	Single copy about 4s. 3d.	W. Engelmann, Leipzig
Zeitschr. Vereines Deutsch. Ing.	Zeitschrift des Vereines Deutscher Ingenieure	Single copy, 1 mark 40 pfg.; 32 marks per annum, post free	J. Springer, Monbijouplatz 3, Berlin

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SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

JANUARY 1900.

GENERAL PHYSICS.

1. *Measurement of Small Elongations.* **G. Ercolini.** (N. Cimento, 10. pp. 241–263, October, 1899.)—Three different methods are described. The first is based upon the measurement of a very small liquid resistance in the gap to be measured, which is introduced as one branch of a Wheatstone bridge arrangement. To avoid polarisation the current is made alternating. In the second method three electrodes are immersed in a solution of sulphate of zinc. Two of them are fixed, and the third, mounted between the other two, is subjected to the small displacement to be measured. The redistribution of the fall of potential is compensated by shifting a corresponding terminal along a straight wire. The third method is non-electrical. A weight is suspended by a bifilar suspension, without freedom of rotation. A small horizontal plate of micra is attached to the middle of the fibres, carrying two magnetic needles and a vertical mirror. When the weight is raised by a slight displacement the needles and the mirror are capable of rotating in a horizontal plane, and will rotate in a suitable magnetic field to an extent depending upon the small displacement. The author uses silk threads for the suspension, and measures distances down to 0·005 mm. E. E. F.

2. *Elasticity of Cement.* **W. L. Brown.** (Instit. Civ. Engin., Proc. 137. pp. 402–409, August, 1899.)—This paper describes researches on the coefficient of direct elasticity of cement and cement mortars, its variation with different kinds and proportions of sand, and with age. The experiments were made on beams 24 inches and 36 inches long, and the deflections under loads were observed with a Ewing extensometer.

The extension is not proportional to the load. A function B is found in the same way as Young's modulus for other materials, *i.e.*, from the formula $B=\frac{W L}{48 I D}$, where W = the increase of load from one point to the next, D the increase of deflections corresponding to this small increase of load; B is therefore the average value of the coefficient of direct elasticity for a variation of load of 1 lb. at that point of the load curve. The value of B for neat cements is greater than for cement mortar, is less as the proportion of sand is greater, and increases with age to a considerable extent. Thus, for neat cement one week old, B=1,850,000 lbs. per square inch, six months old, B=2,800,000 lbs. per square inch. A. S.

3. *Uniform Stress and Permanent Strain in Annealed Copper.* **G. Wilson.** (Manchester Lit. and Phil. Soc., Mem. 43. pp. 1–18, 1899.)—T. E. Stanton showed that the stress in iron varied as the fourth root of the permanent strain. The author's experiments are on copper bars, ⅜ in. diam., 12 in. long, and bring out the fact that in this case the stress varies approximately as the square root of the strain. In one set of experiments each bar operated upon was rapidly subjected to a prearranged load, it was then allowed to stand under this load for a period of thirty minutes, after which the diameter and extension were measured. The stress-strain diagrams obtained differ from those usually drawn by automatic recording instruments. The manner of carrying out the experiments is described.

If P is the load, e the strain due to P, and A the original area, then the stress on the reduced section is $\frac{P}{A}(1+e)$. A relation $f=Ce^n$ is assumed, e being the permanent strain and C a constant. The values of n were found from logarithmic plottings, and the values of C calculated, and the relation $f=87{\cdot}91e^{\cdot 524}$ obtained. The formula $f=\frac{Ce^n}{1+e}$ represents the corresponding stress per unit of original area, and by differentiating, the maximum value of this stress occurs when $e=\frac{n}{1+n}$. For annealed copper the corresponding value of e is 1·101 when n is 0·524, that is 110 per cent., while the corresponding value for iron and steel is 33·3 per cent. The maximum stress for annealed copper should therefore be 18·98 tons per square inch of original area. On testing a bar of annealed copper on the same rod as the previous ones the maximum stress was only 15·5 tons per square inch, with an elongation of 30·3 per cent. Thus, while in iron the theoretical maximum load is actually passed, in copper the theoretical elongation is never reached, and consequently the theoretical maximum stress is not reached.

To obtain a complete diagram before and after the yield point a series of copper wires 20 inches long were tested somewhat beyond the elastic limit. Each wire after fixing was stretched by loading and then carefully annealed. After the test was concluded the wire was reannealed and stretched several times, and again retested. The first test shows irregularities in the elastic portion and that the yield point is not definite, the elastic portion curving into the plastic portion. The test after reannealing shows that the irregularities in the elastic part have disappeared, and that the elastic and plastic portions of the logarithmic curve form two straight lines; further, that the yield point is quite definite and corresponds to a stress of 0·715 tons per square inch. So far as these experiments were carried, repeated annealing and straining have the effect of lowering the yield stress and increasing the value of n, but the author was not able to determine how far the lowering of the elastic limit would continue with further strainings. A.

4. *Elastic Stability of Long Beams.* **A. G. M. Michell.** (Phil. Mag. 4 pp. 298–309, September, 1899.)—A thin, flat bar of elastic material subjected to bending in its own plane may be unstable in the plane form, and fail by combined lateral displacement and twist. The paper is a mathematical investigation of the subject, based on the ordinary approximate equations of bending. It appears that the instability of such a beam is due to the want of torsional, rather than of flexural, rigidity, so that the same kind of instability may affect beams of other forms. The author attempted to verify one or two of the results given by the theory by experimenting on an engineer's st

straight-edge, 4 feet long, 4·87 cms. wide, and 0·26 cms. thick. Tested as a cantilever, the mean critical load was 5,900 grammes, while the calculated critical load was 5,750 grammes. Tested as a beam supported at the ends and loaded in the middle, the mean critical load was 24,200 grammes, while the calculated critical load was 24,250 grammes. The chief source of error in the experiments was the want of uniformity in the thickness of the straight-edge, the thickness varying from 0·2550 cms. to 0·2628 cms.; the divergence, between the observed and calculated results, is no greater than might be expected from this irregularity. A. S.

5. *Geissler Pumps.* **G. Guglielmo.** (N. Cimento, 10. pp. 189–198, September, 1899; also R. Accad. dei Lincei, Atti, vol. 7°, 2° Sem. Ser. 5, fasc. 9. November, 1898.)—Practical suggestions as to improvements in construction. A. D.

6. *Demonstrational Apparatus.* **A. Sella.** (N. Cimento, 10. pp. 176–189, September, 1899.)—Two large flasks (30 litres each), each provided with a stopcock, and connected by a narrow tube with a drop of liquid in it, will show the differences of atmospheric pressure when the whole, after being adjusted and stopcocks closed, is inverted and stopcocks opened. In a slab of slate made up of two strips symmetrically arranged with reference to a mesial line, each strip being cut across the laminæ of the slate, and shaped so that the mesial junction runs at an angle to the lines of cleavage of the slate, upon heating one end of the slab the flow of heat will be parallel to the mesial line, but the isothermal lines, as revealed by the change of colour of iodide of mercury from yellow to red at 40°, will not be at right angles to the mesial line, but form with it angles which depend on the relative conductivities of the slate in two directions. A. D.

7. *Hydrometers of Total Immersion.* **A. W. Warrington.** (Phil. Mag. 48. pp. 498–519, December, 1899.)—The hydrometers and method here described are for the purpose of obtaining the densities of liquids or of solids to the greatest possible degree of accuracy. An accuracy of 1 in 10^6 for liquids and 1 in 10^5 for solids is claimed. The glass hydrometer with mercury, or mercury and the solid inside is weighted by platinum rings dropped over the short stem until it almost sinks in the liquid or the water, and the temperature is then slowly raised until the hydrometer neither sinks nor rises. The temperature is then very accurately read. The whole experiments are done in a thermostat. For a description of the apparatus, the precautions to be observed, and the method of experimenting, reference must be made to the paper.

The coefficient of expansion of Jena glass is determined as—

$$V_t = V_o\,[1+(23{\cdot}714+11{\cdot}62t)10^{-9}t].$$

The temperature of maximum density of water is calculated by G. A. Scholl, in a note to the paper, from the results of the author's experiments. He finds $\tau = 3{\cdot}882^\circ$ C. with a total probable error of $\pm 0{\cdot}024^\circ$ C. The specific gravity of quartz was determined as—

$$2{\cdot}650457 \pm 0{\cdot}000013.$$

The paper contains a large number of tables of experimental data. J. B. H.

8. *Microphonic Record of Chronometers.* **A. Berget.** (Comptes Rendus, 129. pp. 712–718, November 6, 1899.)—An account of a method for obtaining

graphical records from chronometers depending on the microphonic transmission of the beats of the escapement. A light microphone with a vertical carbon is simply placed on the chronometer and put in series with a battery of eight cells and a telephone, on the vibrating plate of which is mounted a microphonic transmitter with four carbons. This transmitter is itself in series with a telephonic receiver, of which the membrane executes, in these conditions, and with the help of a current furnished by four dry cells, vibrations of an amplitude sufficient to break at each vibration a contact established between a carbon point and a sheet of platinum fixed to the membrane. The rupture and re-establishment of this contact are utilised to produce on a moving smoked cylinder a record of each beat made by the escapement of the chronometer. Easily read curves are thus obtained. Amongst other advantages of this method is the suppression of personal error in the observation of the chronometer. J. J. S.

9. *Photography of Ripples.* **J. H. Vincent.** (Phil. Mag. 46. pp. 290-296, 1898, and 48. pp. 338-344, October, 1899.)—The papers are continuations of the articles dealt with in Abstract No. 481 (1898). The work is on similar lines. The first contains an account of experiments which illustrate Doppler's principle and certain interference phenomena. The second contains a description of experiments on the refraction of ripples. A shallow portion of liquid corresponds to the optically denser medium. Both papers are illustrated by reproductions of interesting photographs. A. G.

10. *Determination of Mass of Molecules, and Description of a New Calorimeter.* **H. Gerstmann.** (Deutsch. Phys. Gesell., Verh. 1. pp. 194-208 October 20, 1899.)—By determining the heat of solution of a non-electrolytic substance in a liquid when the former is taken (1) in a lump, (2) in a finely powdered condition, and also the heat absorbed on mixing two such solutions of different concentrations, the author proposes, by the application of a rough theory, to determine the number of molecules in a gramme of the substance and thus the mass of a molecule. His experiments, in which he uses a special modification of Bunsen's calorimeter, have so far given him no other result than that the above two heats of solution differ from each other, as we should expect. He estimates that in the powdered sugar he used there were 15 million particles per gramme. R. E. B.

11. *Size of Molecules.* **G. Jäger.** (Akad. Wiss. Wien., S.ber. 108. pp. 54-5[illegible] 1899.)—The sizes of the ions, or electric carriers in an electrolyte, are here calculated from the specific resistance. The resistance is supposed to be entirely due to viscosity—that is, it is simply due to the viscous resistance which the ions meet with in moving through the liquid. The other assumptions made are : (1) That the ions are spheres. (2) That anion and kathion have equal diameters. (3) That the density of the electrolyte is the true density of the material—*i.e.*, the density is equal to the mass of all the molecules divided by their volume, not including the volume of the intermolecular spaces.

From the expression $w=6\pi\eta v R$ for the resistance to the motion of a sphere in a viscous fluid, the following expression for the diameter of an ion is deduced :—

$$d=\frac{6v}{e}\sqrt{\frac{Mr\eta}{\rho}}$$

where v is the velocity of the ion corresponding to the potential gradient, *r is the specific resistance* of the solution, η is the coefficient of viscosity

M is the molecular weight of the electrolyte, and ρ is the density in the solid (or liquid) state. Applying this to the case of KCl, as with this salt the velocities, and therefore diameters, of the anion and kathion are approximately equal, we find $d=66\times10^{-9}$ cm., while according to the kinetic theory of gases the diameter of the chlorine atom is $d=96\times10^{-9}$ cm. J. B. H.

12. *Conservation of Energy in the Human Body.* **W. O. Atwater** and **E. B. Rosa.** (Phys. Rev. 9. pp. 129–168, September, and 214–251, October, 1899.)—This is an account of an elaborate and careful set of experiments on the income and expenditure of material and of energy in the human body. A calorimetric chamber was constructed, in which a man could live for several days, and was provided with a very complete set of measuring appliances. The chamber was thermally isolated from its surroundings, and a system of electric heaters, and pipes carrying cold brine for cooling arranged so that the internal and external temperatures could (by means of thermocouples) be exactly balanced; hence no heat transfer occurred through the walls, and the entire quantity of heat generated in the chambers was carried off and measured by a current of cold water. The air supply was regulated by means of a combined meter and pump which is described in detail: and the air given out was analysed for carbon dioxide and water vapour. All the food, &c., was carefully analysed, and its thermal value determined by the calorimetric bomb method. The accuracy of the calorimeter was tested (i.) by generating heat in it electrically, and measuring the heat on outflow by the water; (ii.) in order to approach the conditions of experiment more nearly, by burning alcohol in a lamp. The data required (dynamical equivalent of heat, latent heat of steam, &c.) and the sources of error are all duly discussed with the result that the calculated and observed quantities of heat agree to one or two parts per thousand. The same degree of accuracy was obtained in the measurements of carbon and hydrogen taken in and given out in the alcohol experiments.

Experiments on a human subject are then described. The energy spent per day when the subject rested, was about 2,310 cals.; when doing 256 cals. of work it amounted to 3,726 cals., giving an efficiency of 7 per cent.

R. A. L.

13. *Investigations in Capillarity.* **Rayleigh.** (Phil. Mag. 48. pp. 321–337, October, 1899.)—The article is divided into four parts, which are comprised under the headings, (1) the size of drops, (2) the liberation of gas from supersaturated solutions, (3) colliding jets, (4) the tension of contaminated water-surfaces.

Neglecting viscosity, the mass of the drop delivered from the lower end of a vertical tube is given by the equation $Mg/Ta=F(T/g\sigma a)$, where M is the mass of the drop, g the acceleration due to gravity, T the surface tension, a the external radius of the tube (liquid supposed to wet the tube), σ the density of the liquid, and F an arbitrary function. Within certain limits the author experimentally determines the nature of the arbitrary function; hence, within the limits, the surface tension of a liquid can be calculated when the size of a drop and certain other quantities are known. An approximate equation is $Mg=3{\cdot}8\,Ta$.

The author does not come to a decisive opinion with regard to the explanation of the liberation of gases on surfaces in supersaturated solutions. The activity of iron wires was destroyed by heat, and they were sealed in glass tubes containing air. After long periods, on taking out of the tubes,

they were found to be inactive, but exposure to the air of the laboratory for a day or two restored activity.

In the section on colliding jets, the author shows that just before two jets coalesce the viscosity of the intervening gas must play an important part. The solubility of the gas assists coalescence—a fact confirmed by experiments.

The fourth section contains a description of experiments carried out with the aid of the trough of Miss Pockels. The conclusion is confirmed that, judged by the drop in surface tension, the effect of contamination by oil comes on suddenly; and curves are drawn which show the relation between the degree of contamination and surface tension. One explanation of the cause of the fall in surface tension leads to the conclusion that the first fall in the surface tension corresponds to a complete layer one molecule thick, and that the diameter of a molecule of oil is about 1×10^{-7} cm. Another less probable explanation gives a different result. A. G.

14. *Efflux of Permanent Gases.* **R. Emden.** (Wied. Ann. 69. 2. pp. 426–453, October, 1899.)—The present paper contains the mathematical theory of the efflux of gas under pressure. The author starts from the position that, if the efflux is steady, equal masses and equal quantities of energy must pass the space between two cross-sections of the tube in each unit of time and he arrives at some important generalisations. The velocity with whicl the gas passes the orifice can never become greater than the velocity o sound at that point. This maximum velocity holds good when the critica ratio of pressures obtains between the internal and the external pressure This singular pressure at which a gas-jet emerging into the atmospher begins to pass the orifice with the velocity of sound, corresponds to th velocity of efflux at which stationary sound waves are formed in the je After the critical ratio of pressures is passed, the jet issues at all points wit the velocity of sound, and at every point the pressure is that of the atmospher The author points out that in this manner sound waves of very small wav length and very high frequency may be produced, possessing greater energ than any yet produced. E. E. I

15. *Theory of Diffusion.* **E. Bose.** (Zeitschr. Phys. Chem. 29. p 658–660, September, 1899.)—The paper gives the theory of the diffusi of a partially ionised electrolyte which breaks up into two ions.

Let c_u equal the concentration of the unionised part; c_d the concentrati of the ionised part; and c the combined concentration. (Thus $c=c_u+c$ The relationship between c_u and c_d in certain cases and between certa limits is given by the equation $k.c_u=c_d^2$.

In the case of a cylinder of length l, and cross-section q, one end of whi is at a concentration c_1, the other c_2, the quantity S transmitted in time z wh a steady state has been attained is given by the formula,

$$S=RT.\frac{q}{l}.z.\left[W(c_2-c_1)+2\left(\frac{UV}{U+V}-W\right)\left(\sqrt{\frac{k^2}{4}+kc_2}-\sqrt{\frac{k^2}{4}+kc_1}\right)\right],$$

where R and T are the quantities which occur in the equation $pv=RT$; is the velocity produced by unit force acting on the gramme-molecule of unionised electrolyte; and U and V are corresponding velocities for the ic Attention should be paid to the hypothesis that $kc_u=c_d^2$. The form indicates that strictly there is not a constant of diffusion. The aut suggests that the formula should be tested by experiments with an electrol like acetic acid. A

16. *Densities of Saturated Vapours.* **R. von Hirsch.** (Wied. Ann. 69. 2. pp. 456–478, October, 1899.)—The author investigated the critical densities of toluol, xylol, propionic acid, and butyric acid by Young's method of enclosing two different quantities of the substance in a sealed glass tube and observing the disappearance of the meniscus in the two cases. He comes to the conclusion that in the temperature-density curve the critical temperature line is not a tangent to the curve of densities, but that the curve meets the line in two points close together. Above the critical temperature the density of the substance is represented by an ordinate whose position can be altered between certain limits by the filling of the tube. When the critical temperature is exceeded, there is always an abrupt change of density. Such a change of density could not take place if solid and liquid had the same density, since the volume is constant and the weight unalterable.

E. E. F.

17. *Explosions in Air.* **W. Wolff.** (Wied. Ann. 69. 2. pp. 329–371, October, 1899.)—The energy of explosion of a body is determined by its weight and its heat of explosion. It is spent in destruction at the seat of explosion, in earth tremors, in the motion of projected matter, and in the vibration and motion of masses of air. If the latter impinge upon a body, the quantity of energy absorbed by it depends upon its properties. If the body is absolutely hard and firm, it reflects all the incident energy. The author has, on behalf of the Prussian Artillery Testing Commission, made some experiments at Cummersdorp to determine the type of motion produced in the air by an explosion. He finds that the type is essentially that of the sound wave, though the velocity of propagation increases with the violence of the explosion. The main difference lies in the fact that the explosion produces a finite condensation, whereas the condensation in a sound wave is infinitesimal. As the wave passes away from the origin its velocity of propagation decreases, so that the wave-front becomes steeper. There is no bodily translation of air to distances over some 25 m. But the translation within that radius leads to a subsequent wave of rarefaction, which is propagated with nearly the same velocity as the primary wave, and accounts for the indirect effects of the explosion, and for the projection of bodies towards the origin. E. E. F.

18. *Mass of a Cubic Decimetre of Water.* **C. Fabry, J. M. de Lépinay, and A. Pérot.** (Comptes Rendus, 129. pp. 709–712, November 6, 1899.)—The authors have previously described the method adopted to measure in wave-lengths the dimensions of a parallelopiped of quartz, of edge about 4 cm. Their object was to determine the volume of this solid in view of a new determination of the mass of a cubic decimetre of water. The faces of the solid being neither perfectly plane nor parallel two and two, it is necessary to investigate how the thickness varies from one point to another in each pair of faces. The optical methods adopted to obtain these differential measurements are described in the present paper, and from these measurements the trace of the curves of equal thickness for the three pairs of faces is obtained. Having these curves as well as the absolute thickness at one point, the mean thickness corresponding to the pair of faces considered is obtained by means of the planimeter. The volume of the cube of quartz deduced from the measurements is 61·75136 cc. On the other hand the mass of water at 4° displaced by this solid was exactly known from determinations of its mass and its density. This mass of water is 61·75004 grs. Hence the mass of 1000 cc. at 4° is 999·9786 grs., or 1 kilogr. — 21·4 milligrs. This result is considered exact

within a few milligrammes. It agrees with the number which Chappuis has obtained as a provisional result of measurements made on cubes of glass by Michelson's method, viz., 1 kilogr. — 24 milligrs. J. J. S.

19. *Air-Resistance to Projectiles.* **R. Emden.** (Wied. Ann. 69. 2. pp. 454–455, October, 1899.)—The additional function of the velocity which makes up the total resistance of air encountered by a projectile suddenly increases between the velocities of 300 to 400 m. per second, but is approximately constant above and below that value. The author offers the following explanation: The projectile has to perform work in overcoming the air resistance. This work increases as soon as the velocity has increased to such an extent that Mach's conical head-wave is formed. This head-wave is formed as soon as the projectile attains the velocity of sound. But every sound wave contains a certain amount of energy, and this energy must be derived from the kinetic energy of the missile. The expenditure of energy increases until the head-wave has attained its maximum intensity. It must always be newly generated, but the additional resistance is constant after the maximum intensity is reached. This would explain what is found to occur, but the existence of a maximum intensity of the head-wave remains to be demonstrated.

E. E. F

20. *Production of Waves in an Elastic Solid.* **Kelvin.** (Phil. Mag. 48 pp. 388–393, October, 1899.)—This is the concluding portion of the memoi (see 1898, Abstracts Nos. 1120 and 1631). The cavity in the elastic solid i supposed to have a rigid massless spherical lining called the sheath. A mas m is mounted on massless springs within the sheath. The author investigate what must be the force in simple proportion to the velocity of m which wi keep the sheath vibrating in simple harmonic motion $h \sin \omega t$, and therefor will do the work of sending out the two sets of waves treated in the forme numbers. The velocities of the equivoluminal and irrotational waves are and v respectively; q is the radius of the sheath. Two cases are considered (1) $q\omega$ is very large compared with the greater of u and v; (2) $q\omega$ is ve small compared with the smaller of u and v. Then, c denoting the stiffne of the system of springs, the results are considered according as c is ve small or infinite. Then he considers the case of v being infinite, which important in the Dynamical Theory of light. Lastly, the example suggest in Phil. Mag., March, 1899—a large mass of granite with a spherical hollo of 10 centimetres diameter acted on by an internal simple harmonic vibrat of $1006\frac{1}{2}$ $\left(1000\sqrt{\frac{10}{\pi^2}}\right)$ periods per second, and again when it has 1·00 periods per second. S. H.

21. *General Equation for Free Energy and Physico-Chemical Equilibriu* **G. N. Lewis.** (Amer. Acad., Proc. 35. pp. 3–38, July, 1899.)—In Part I. this paper the author obtains a perfectly general expression, equation (6), his work, for the change of free energy in any isothermal change, chemi or physical, in any system, whether homogeneous or heterogeneous. He th applies it to the case of gases and dilute solutions, and deduces a gene equation for equilibrium in any system, leading with some extension to t mass law of Guldberg and Waage, and also that of Henry.

In Part II., treating of monomolecular systems, he shows that an equati nearly identical with that of van der Waals can be deduced from his gene equations by the aid of two empirical observations, namely, the constancy

the specific heat of gases at constant temperature, and the proportionality between the cooling effect and the fall in pressure in the free expansion of gases. Instead of van der Waals' constant b, he obtains an undefined function of the volume. For van der Waals' constant a in $\frac{a}{v^2}$ he would also use a function of the volume. He proposes a more general equation recognising the variability of specific heat with volume. A formula is obtained for equilibrium between a liquid and its vapour. The vapour pressure curve is also discussed.

In Part III., the application of the general equation to solutions leads to expressions for osmotic pressure and osmotic work in concentrated solutions, and an equation is given for the distribution of a solute between two solvents.

In Part IV. the influence of the nature of the solvent on general homogeneous equilibrium is discussed.

Part V. deals with the application of the general equation to electrochemistry. S. H. B.

22. *Formation of Clouds with Ozone.* J. S. **Townsend.** (Cambridge Phil. Soc., Proc. 10. pp. 52–58, 1899.)—When ozone is bubbled through a solution of potassium iodide, a cloud forms over the solution. In explanation, Meissner has suggested that the silent discharge produces both ozone and antozone, and that the antozone, after the removal of the ozone, condenses water. The author prepared ozone from pure oxygen in a Babo apparatus, consisting of two sets of fine glass tubes containing platinum wires, enclosed in a large glass tube. A large flask is partly filled with water. Gases can be introduced through two tubes, not dipping into the water; the one brings dried ozonised oxygen, the other oxygen which has passed over—not through—a solution of potassium iodide. No cloud is formed over the water. But when some iodine is dissolved in the iodide, then a cloud appears where the two gas streams meet. The cloud cannot be due to spraying, since the tubes do not dip into the water. The clouds seem to be produced by the action of ozone on the iodine vapour which the stream of oxygen had carried with it, and they consist mainly of water vapour. A solution of sulphur dioxide gives similar results. Bubbling the oxygen through the iodide or through a solution of metabisulphite of sodium also gives clouds, which become denser when the solution is gently heated; sodium sulphite gives no cloud. The ozone seems to oxidise the iodine or sulphur dioxide, yielding, in the presence of water, iodic or sulphuric acid. The cloud disappears when the gas is dried by passing through sulphuric acid, and reappears in the presence of moisture. There remain behind in the gas, says the author, very small particles which consist of the non-volatile body which prevented the drops forming the cloud from evaporating under the action of surface tension. In order to ascertain whether or not the centres round which the drops form are electrically charged, the gases which were capable of producing a cloud were passed through an aluminium cylinder whose insulated axis was connected with a quadrant electrometer. No change could be detected. H. B.

23. *Newtonian Constant.* G. K. **Burgess.** (Comptes Rendus, 129. pp. 407–409, August 21, 1899.)—This is a description of a piece of apparatus used in Lippmann's laboratory for the determination of the gravitational constant. W. G. R.

24. *Gravity in Piedmont.* **C. Aimonetti.** (Accad. Sci. Torino, Mem. 84. pp. 550-561, 1899.)—The chief results are given in the following table :—

Stations.	Gravity observed.	Correction for height.	Correction for Mass underneath.	Gravity reduced to sea-level (G'$_0$)	Gravity theoretical (G$_0$)	Anomaly of gravity (G'$_0$—G$_0$)
Fossano	9·80430	+116	−31	9·80515	9·80556	— 41
Cuneo	437	163	52	548	541	+ 7
Alba	465	52	18	499	569	— 70
Alessandria..	468	25	8	485	589	—104
Voghera	470	30	9	491	596	—105
Asti	471	38	13	496	587	— 91
Chivasso	546	55	19	582	614	— 32
Crea............	417	136	44	509	605	— 96
Vercelli	564	40	12	592	626	— 34
Novara	611	49	15	645	637	+ 8
Turin	570	72	24	618	603	+ 15

Considering a line from Turin to Milan, it is seen that there is an excess (mass at Turin, a deficiency at Chivasso and Vercelli, and again a slight exce at Novara. Along a parallel line, from Cuneo to Voghera, after a slight exce at Cuneo, there is a deficiency whose value increases gradually until Voghe is reached, where the deficiencies are greater than at Chivasso and Vercelli.

A. (

25. *Humidity Variations on the Coast of the Adriatic.* **E. Mazelle.** (Ak Wiss. Wien., S.ber. 108. pp. 281-322, 1899.)—Hourly observations were tak during the ten years 1886-1895, all with the same thermo-hydrograph of Has and Escher, at the Navy Hydrographic station of Pola. The hut has since be arranged in modern fashion, so that comparative data will be available so years hence. The maximum relative humidity was observed at 4·3 h. a.m. January, at 6, 5·9, 5·4 h. in the following months, at 4·9, 4·6, 4·7, 4·4, 4·4 h. dur the summer up to September, and at 5·9, 6·8, 5·2 h. a.m. in the last months the year. Thus the maximum precedes the sunrise in winter and chan little as to the hour during the summer months. The minimum follows 1·7 h. p.m. in January, and about 0·5 h. p.m. in summer. When serene d (uninterrupted sunshine record) and overcast days are distinguished, amplitudes of the relative humidity are found to be greater on serene d and in summer generally (maximum in July), than on overcast days and winter (minimum in November). The extremes are delayed in winter spring, and advance as the season passes from summer into winter. W of relative humidity, a continued general increase followed by a decre have an average length of 3·16 days; they are a little shorter in sum and longer in winter. As a rule the ascending branch is longer than period of decrease. The paper is essentially tabular; curves are not gi

F

26. *Kites for Meteorological Research.* **C. F. Marvin.** (Frank. In *Journ.* 148. pp. 241-259, October, 1899.)—The U.S. Weather Bureau seventeen kite stations in 1898, of which, owing to limited funds, only t were in operation at the end of the year. The work is under the superint

ence of the author. The standard kite is of the Hargrave type with three frames of spruce strips—straight, not curved—braced and strengthened by steel wire ties. The two bands, the one of white cambric, the other of black percaline, are 2 feet wide and 28 inches apart. The bridle cord is attached at a single point, well forward; the safety line is also a cord, not an elastic spring or cord as often proposed. The steel wire of the line 0·028 inch in diameter, has a tensile strength of over 200 lbs. and is applied in lengths of 7,000 feet The hand-reel on which it is coiled (at Washington a steam windlass) must be exceedingly strong. The inclination of the line is measured with the help of aluminium arms and a graduated circle; the angular elevation by the Marvin nephoscope, a mirror with an adjustable sighting staff, through which and through the centre of the mirror a weighted thread passes. In the line inclination, a correction is made for the sag, not for the lateral wind pressure on the wire. The Marvin meteorograph is fixed within the box-frame of the kite, and not suspended below the kite, and consists of a drum, revolving once in twelve (or in one) hours, and a tube parallel to it through which the wind blows. The tube contains the hair hygrometer and the thermometer, a pair of Bourdon tubes completely filled with alcohol. The lag of the thermograph is 1° F. when the temperature changes at the rate of 1·5° per minute, which corresponds to the ordinary rise or fall of the kite, 500 feet per minute. The aneroid barometer has a steel chamber. The wind velocity is measured by anemometers. Four pens rest on the drum. H. B.

27. *Laziale Earthquake, July* 19, 1899. **C. Bassani.** (Rivista Sci. Industriale, 31. pp. 169–171, August 10, 1899.)—According to the author's calculations the seismic centre was under Monte Cavo at a depth of 16·12 kilometres; and the total energy of the shock was $1·5 \times 10^{16}$ kilogram-metres.

A. G.

28. *Seismometric Observations in Göttingen.* **E. Wiechert.** (Gesell. Wiss. Göttingen, Nachr. Math. Phys. Klasse, 2. pp. 195–208, 1899.)—The observations are taken by means of a seismograph consisting of a horizontal pendulum, one end of which presses against a point, whilst the other is supported by a thread. The pendulum is of a conical shape; it is almost surrounded by a fixed cone; the intervening space is only a few millimetres across, and the air-damping is considerable. The whole is surrounded by a cover provided with a glass window. The free extremity of the pendulum is provided with a mirror, and, by suitable means, any motions are registered photographically on a rotating cylinder. The yearly cost of the photographic paper, gas, &c., for one pendulum is about 170 marks. Two, which would enable the components of the earth-disturbances in two directions to be determined (the same lamp would do for the two), would cost about 280 marks yearly. Apart from seismic actions, the pendulum is subject to two disturbances: shaking arising from the action of wind upon the building, and movements of the support due to changes of temperature. Experience teaches how to distinguish between these disturbances and the seismic actions. The instrument is proving a serviceable one, and some interesting reproductions of the graphs show that it has recorded the earth-movements due to earthquakes with centres at great distances. A. G.

29. *The Solar Corona.* **T. Bredikhine.** (Acad. Sci. St. Pétersbourg, Bull. 8. pp. 179–207, 1898.)—*Using photographs of* the sun's corona, the author *graphically determines the various hyperbolic* paths along which the coronal

matter appears to move, by placing hyperbolic curves with their foci at the sun's centre, and trying consecutive curves until one is found to fit a particular path (the effect of perspective, which is readily noticeable in some cases, being neglected). From the observed velocity of solar protuberances, the author is led to form an estimate of the probable initial velocities of the coronal matter; these may range from 200 to 600 kilometres per sec., and in some cases may reach even 900 kilometres per sec. The author points out the close analogy between the tails of comets and the sun's corona, and, making the assumption that each particle describes its path under the action of two forces—a gravitational attracting force due to the sun's mass, and an unknown repelling force—calculates the value of this latter from the graphically determined paths and the assumed initial velocities. The result of this investigation is to show that the force of repulsion either very nearly balances that of attraction, or else differs from it by only a small amount. In general, the coronal matter which is being ejected from a given point on the sun's surface will, at a given instant, have the form of a spiral consisting of one or more turns, according as the period of eruption does not or does exceed the time of the sun's revolution. The various portions of this spiral move outwards almost exactly along their radii vectores. The author then throws out several suggestions regarding the causes of these eruptions: it is possible that when portions of the sun's substance originally in its interior are quickly brought to the surface, the sudden release from an enormous pressure causes a violent scattering of the particles; again, under the influence of the sun's atmosphere the ionised particles may conceivably be deprived of the electric charges of one sign, those of the opposite sign only remaining; the force of repulsion might then be explained as due to the electric potential of the sun. In conclusion, the author refers to the work of Bigelow and Schaeberle on this subject. A. H

REFERENCES.

30. *Elastic Deformations of a Reversion Pendulum.* **E. Almansi.** (N. Cimento 10. pp. 85–111, August, 1899.)—A further mathematical investigation of the internal forces normal to the movable axis. (See 1899, Abstract No. 1460.) E. E. I

31. *Dynamical Theory of Capillarity.* **G. Bakker.** (Journ. de Physique, 8. pp. 545–552, October, 1899.)—A mathematical paper dealing with the bearing of cohesion molecular pressure, internal heat of evaporation, &c., on surface tension. (See also 1899, Abstract No. 1320.) A.

32. *Units of Measurement.* **W. Moon.** (Elect. Rev. 45. pp. 736–737, Nov. and pp. 861–862, Nov. 24, 1899.)

33. *Reflection and Refraction of Elastic Waves.* **C. G. Knott.** (Phil. Mag. pp. 567–569, December, 1899.)—Correction to C. G. Knott's paper (see 1899, Abstract No. 1633), pointed out by T. Gray.

34. *Physical Life of the Earth.* **A. Klossovsky.** (Revue Scientif. 12. pp. 28 295, September 2nd; pp. 364–369, September 16th; pp. 424–429, September 30 1899.)—This is an interesting review of the various physical phenomena, atmosphe and terrestrial, observed from the earth's surface, and their possible explanation the application of electrical theories. The paper is too discursive to abstract detail. C. P.

LIGHT.

35. *Refractive Index of Liquids, II.* **C. Bender.** (Wied. Ann. 69. 3. pp. 676–679, November, 1899.)—This part of the author's work deals with the refractive index of water for the three lines $H\alpha$, $H\beta$, and $H\gamma$, between the temperatures 40° and 70°. For $H\alpha$ the refractivity of pure water is represented by the formula $1{\cdot}3319977 - 0{\cdot}0000237 2t - 0{\cdot}0000011362t^2$. For $H\beta$ the first term is 1·3377690, and for $H\gamma$ it is 1·3409663, the temperature coefficients being the same for all the three lines. (See 1899, Abstract No. 1471.) E. E. F.

36. *Double Refraction in Liquids.* **B. V. Hill.** (Phil. Mag. 48. pp. 485–498, December, 1899.)—The double refraction introduced in solutions of colloids by stirring is here studied. The solution was placed in a bath which contained also two parallel cylinders, one of which was rotated. (See Phil. Mag. 44. p. 499.) The light passed through the solution between the cylinders. A half-shadow apparatus was used to measure the rotations. Homogeneous light obtained by passing sunlight through absorbing solutions was used. Solutions of the colloids gelatine and gum-arabic and the crystalloids hyposulphite of soda and cane-sugar were studied. With the crystalloids no double refraction is observed, but with the colloids the double refraction varies with the speed of rotation of the cylinder and also with the concentration. With a solution of gum-arabic the double refraction is proportional to the speed, but not proportional to the concentration; but in this respect the effect depends very much on how the solutions have been treated and made. With solutions of gelatine, for small velocities the double refraction increases with the speed, though not in proportion to it. This increase continues up to a certain point, where an elastic limit seems to be reached. Beyond this point the amount of double refraction decreases and finally changes sign as the speed is increased. With very dilute solutions (1 gramme per litre) this breaking down takes place at so small a speed that it cannot be observed, and the decrease of the double refraction with the speed is very slow. In solutions of gelatine under the same conditions the double refraction is proportional to the concentration. A number of tables and curves are given in the paper.

The author concludes that these solutions of colloids are not true solutions in the proper sense of the term, since their behaviour is much more like that of an elastic solid, being able to sustain strains if not distorted too much. Also, if diluted to half the concentration, the double refraction is indefinite and is not halved until the solution is again boiled and cooled. There must therefore in these solutions be a structure similar to that of jellies. J. B. H.

37. *Strain in Glass Drops.* **K. Mack.** (Wied. Ann. 69. 4. pp. 801–803, December, 1899.)—Strained glass plates show striking colours in polarised light. Glass "tears" appear black owing to total reflection. But they can be made to show their colours by immersing them in a glass trough containing a liquid of the same refractive index, such as cedar oil, or a mixture of carbon bisulphide and ethyl ether, or a solution of chloral hydrate in glycerine. The colours resemble those of peacock feathers or butterfly wings. They make a striking lecture experiment. E. E. F.

38. *Focussing a Collimator.* **G. Lippmann.** (Comptes Rendus, 129. pp. 569–570, October 16, 1899.)—The slit is viewed through an auxiliary telescope, and a bi-plate is interposed between the telescope and the collimator. The bi-plate consists of two plates of glass with their edges adjoining

and parallel to the slit, and their surfaces at right angles to each other and at 45° to the path of the beam. Two images of the slit are then seen in the telescope. The collimator is focussed until the two images become one. When that happens it is focussed upon infinity as required. E. E. F.

39. *Correction for Thickness of Lens and Mirror in Magnetometers.* **S. Hlasek.** (Acad. Sci. St. Pétersbourg, Bull. 9. pp. 83–90, 1898.)—It has recently become common practice to close the opening through which the light passes into the chamber containing the suspended magnet by a lens instead of a plane piece of glass, as this arrangement requires only an eyepiece for reading off the deflection, and is thus cheaper. The formula which is generally used for calculating the corrected distance of the scale is—

$$e_o = e\left\{1 - \frac{d(e-d)}{ef}\right\}$$

where e_o and e stand for the corrected and measured distances respectively of the scale from the mirror, d for the distance of the lens from the mirror, and f for the focal length of the lens. The author points out that this formula may lead to appreciable errors, since it takes no account of the thickness of the lens, and since neither e nor d are sufficiently well defined. He then deduces the following more accurate formula—

$$e_o = e\left\{1 - g\frac{e-g}{ef} + \left(\tfrac{2}{3}\delta - \tfrac{\Delta}{3}\right) \cdot \frac{f-g}{ef}\right\},$$

in which $g = d + \frac{2}{3}\delta + \frac{\Delta}{3}$, d being here the distance of the front plane of the mirror from the lens surface facing it, δ the thickness of the mirror, Δ that of the lens, and e the distance of the scale from the front plane of the mirror.

A. H

40. *Mechanical Working of Optical Surfaces.* **P. Gautier.** (Journ. de Physique, 8. pp. 477–483, September, 1899.)—The truth of a plane surface is best tested by means of a round luminous patch reflected at a large angle of incidence. When in focus, the patch, observed through a telescope, should be round and surrounded by symmetrical fringes. If the surface is slightly concave, the image will be flattened out laterally on pulling out the eyepiece if convex, the image will be drawn out vertically. An elevation of only 0·0001 mm. is thus discoverable. In order to avoid bending, the glass must be so thick that a mirror 2 m. in diameter would weigh 8,000 kilogrammes. The working machine must be correspondingly rigid. The machine used for the 2 m. mirror is described. The working occupied three months. The last polish was done in the dry way with paper attached to the grinding surface and lightly rubbed with the finest Tripoli powder. During the operation it was found necessary to keep a distance of 0·03 mm. between the polishing surface and the mirror. After every two minutes' polishing the machine had to be stopped for half an hour to avoid heating. Eventually was found necessary to give the grinding surface a curvature of 0·005 mm. fo the 2 m. The mechanical correction lasted eight months. E. E. F

41. *New Spectrophotometer.* **D. B. Brace.** (Phil. Mag. 48. pp. 420–48 November, 1899.)—An ordinary spectrometer by the addition of an ext collimator and with a particular prism on the goniometer table is here co verted into a spectrophotometer of the most sensitive type. This type is o having no line of separation between the fields to be compared, as realised the Lummer-Brodhun ordinary photometer. The prism is a composite or composed of two equal prisms whose angles are 30°, 60°, and 90°, cement

together so as to make an equilateral triangular prism. One of the two faces cemented together has a strip silvered along its whole length.

Suppose the prism to be mounted on the spectrometer table, and the two collimators to be placed symmetrically to the cemented faces, and in such positions that the two beams from the collimators enter the composite face of the equilateral prism from opposite sides at the angle of minimum deviation. The two beams, or portions of the beams when they emerge from the prism, the one after direct transmission through the cemented faces, the other after reflection in the silvered part of the cemented faces, emerge as spectra, exactly coinciding the one with the other. The instrument is adjusted so that the sodium line of each spectrum coincides with the cross wires in the telescope ; any other line in the one spectrum then coincides with the same line in the other. If the eyepiece of the telescope be now removed and a small vertical slit be inserted in the focal plane, the eye, by focussing on the prism through the slit, will see the field illuminated by monochromatic light, and with a band across it which is brighter or less bright than the rest of the field. By adjusting the width of one of the collimator slits the band will disappear, and the two spectra are then of equal intensity for that particular wave-length. By this means any two sources of light may be compared throughout the whole spectrum.

The author describes a convenient method of standardising the slits.

J. B. H.

42. *Spectrophotometry of Electric Light.* **F. Gaud.** (Comptes Rendus, 129. pp. 759–760, November 18, 1899.)—Incandescent and arc lights were compared with sunlight. Each of the lights was decomposed by glass screens of homogeneous colours, and the intensity of the transmitted beams was estimated by Foucault's or Bunsen's photometric apparatus. The light transmitted by the screen was observed by means of a grating, and the angles of deviation measured. Thus the wave-length of the radiation from each screen was found very exactly. Then the sources to be compared were arranged on the photometer, furnished each with a yellow screen, so as to obtain equality of illumination for the D ray. On substituting for the yellow screen the series of coloured screens it was necessary each time, in order to get equality of illumination, to modify the distance of one of the sources, which instead of L became L_1, L_2 . . . The numbers $\left(\frac{L_1}{L}\right)^2$, $\left(\frac{L_2}{L}\right)^2$, . . . measure the photometric ratio of the two lights for each colour considered. Taking these numbers as ordinates with the wave-lengths of the corresponding colours as abscissæ a curve is obtained which gives the exact measure of the ratios for the principal rays of the spectrum. The following is a table of these ratios :—

Wave-length.	Incandescent Light. Sun.	Arc Light. Sun.
800 μ	11·86	1·67
Ray A	4·88	1·37
,, B	2·68	1·28
,, C	1·25	0·97
,, D	1·00	1·00
,, E	0·38	0·77
,, F	0·17	0·56
,, G	*0·10*	0·83
,, *H*	*0·05*	1·21

J. J. S.

43. *Photometry of Acetylene.* **L. W. Hartman.** (Phys. Rev. 9. pp. 17(
188, September, 1899.)—An account is given of the photometric study (
mixtures of acetylene and hydrogen burned in air. The results are exhibite
by means of curves. From these it appears that the acetylene-hydrogen flan
is richer in the short wave-lengths than the flame burning acetylene alor
used as a secondary standard. Moreover, the colour properties of the flan
appear to be independent of the amount of hydrogen in the mixture. Upc
going to the limit this statement would not hold true. Lava tip and bra
tip burners were used. In the case of the brass tip it is shown by curv
giving the relation between percentage of acetylene and candle-power, th
the candle-power reaches a maximum and then falls away with increasin
percentage of acetylene. This is due to the incomplete combustion of the g
after a given percentage of acetylene in the mixture has been reached. I
the case of the lava tip, the flame with low percentages of acetylene appea
very like the flame of burning hydrogen : at first it slowly increases in candl
power with increasing percentage of acetylene, and does not reach the stag
of incomplete combustion. J. J.

44. *Photometry of Arc Lamps.* **F. Laporte.** (Soc. Int. Élect., Bull. 1
pp. 288–302, June, 1899.)—The author describes a method of measuring th
total mission of an arc lamp by reflecting its light into a photometer by
mirror capable of travelling in a circle round the lamp, the rotation takin
place about the axis of the photometer. In practice two such mirrors are use
E. E. I

45. *Photometry of the Electric Arc.* **E. W. L. Richter.** (Elekt. Rund
16. pp. 238–239, August, 1899.)—The electric arc is divided into three part
(*a*) a green-tinged aureole, (*b*) a darker mantle of flame, (*c*) a bright blu
violet nucleus. The relative actinic intensities of these three parts depe
very much upon the kind of carbons used. Experiments are described i
which a Nicol's prism photometer is employed for comparing the appare
relative intensities, using in some cases carbons with a known percentage of
salt, such as sodic chloride. In one case mentioned, using solid carbo
13 mm. diameter, with an arc-length of 6 mm., 15 amperes, and 56 volts, th
ratios are—

$$b : a : c = 1 : 2{\cdot}28 : 3{\cdot}32.$$

The brightness of the sodium line is greater in *a* and least in *b*, and is
function of the temperature and of the quantity of sodium vapour. R.

46. *Maximum of Radiation.* **F. W. Very.** (Astro-Phys. Journ.
pp. 208–210, October, 1899.)—The author discusses some courses of observ
deviations from Paschen's law,

$$\lambda_{max} \times T = 2891.$$

"Two causes conspire to produce these differences. (1) The imperf
absorption of long waves by the simply blackened bolometer makes the wa
length of the apparent maximum too small, and this to a greater degree as
temperature is lower and the maximum in the spectrum nearer to these lo
waves whose absorption by the blackening substance becomes less and l
as the wave-length increases. (2) The temperatures of thick radiating pl
are estimated too high, on account of neglecting the sub-surface temperatu
gradient which is larger and increases the assigned maximum more,
higher the temperature. The first of these causes of error is eliminated

Paschen's recent work by the use of what may be called a repeating bolometer, in which the strip has repeated opportunities for absorbing the reflected remnant of radiation; and the second has been obviated by the use of radiant cavities and extremely thin radiant strips, reducing the sub-surface gradient to a minimum." E. E. F.

47. *Remnant Rays of Fluorspar.* **H. Rubens.** (Wied. Ann. 69. 3. pp. 576–588, November, 1899.)—When the radiation of any source of heat is repeatedly reflected from fluorspar surfaces, the emergent rays all belong to a certain infra-red region from which fluorspar exhibits metallic reflection. The author calls these rays remnant rays (*Reststrahlen*). Their wave-length varies between 24·4 and 28·7 μ. The energy curve is unsymmetrical, being steeper on the more refrangible side. A new examination by means of an improved thermo-couple reveals the existence of a second maximum in the energy-curve, situated at $\lambda = 31{\cdot}6$. It is the clearer the greater the number of reflections. E. E. F.

48. *Propagation of Luminous Vibrations through Matter.* **G. Sagnac.** (Comptes Rendus, 129. pp. 756–758, November 18, 1899.)—The author considers the luminous vibrations in the interior of a body as being propagated by the intervention of a medium identical with the ether of a vacuum, and not differing from it in density or elasticity. Instead of considering mechanical reactions between the ether and matter, account is taken of the *discontinuity of matter* by a mechanism chiefly kinematic, as follows :—

Each particle or atom of the material medium sends back in all directions a definite proportion of the vibrations which fall upon it. This reflection-diffraction of the luminous vibrations by a material particle may be compared to the reflection-diffraction of Hertz's electric vibrations by a small conducting body *in vacuo* of very small dimensions compared with the wave-lengths of the incident electric vibrations. Consider the fundamental case of a series of plane luminous waves of single period arriving in a vacuum parallel to the plane surface P of a very transparent isotropic medium. Each layer of particles of the medium separates the vibrations which meet it into transmitted and reflected vibrations. The same subdivision goes on by transmission and reflection at the different layers of particles. There is thus produced a number (theoretically infinite) of systems of elementary vibrations having undergone transmissions and reflections more or less numerous. All the elementary vibrations which have undergone an even number of reflections at the particles are propagated towards the interior of the material medium. At the same plane S, parallel to the surface P of the medium, these vibrations arrive with different phases on account of the different paths that they have traversed *in vacuo* from one reflecting particle to another. The resultant of these elementary vibrations of even order defines at each free point of the plane S the periodic vibration transmitted to the interior of the medium. In the same way the elementary vibrations which have undergone an odd number of reflections come back to traverse the surface P of the medium; their resultant defines, at each free point of P, the vibration reflected at the surface of the medium.

When the plane S withdraws into the medium to a distance from the surface P superior to a certain value E, the vibrations of uneven order which traverse the plane S *in the direction of P* are sent back by the layers of particles *comprised between S and P sensibly* as if the distance e from S to P was *infinite. After this, the same increase* Δe of the thickness e of

matter between S and P produces always the same increase Δr of the retardation r of the refracted vibration. The retardation r is considered as the mean, determined by the rule of Fresnel, between the different retardations δ that the different elementary vibrations of even order have experienced during their course back and forward *in vacuo* between the reflecting particles. The elementary retardations δ increase by successive degrees comparable to double the mean distance of the particles; therefore, in general, by degrees extremely small compared with a wave-length. All these retardations δ surpass the thickness e of the medium traversed: the ratio, $\frac{\Delta r}{\Delta e}$, henceforth constant, is above unity; it is the *index of refraction*, n, of the medium. According to this mechanism, the velocity of propagation of the transmitted vibration takes a constant value V equal to V_0/n (the velocity of a plane wave *in vacuo* being V_0), only beyond the optical layer of passage determined by the thickness E of the medium supposed perfectly homogeneous. J. J. S.

49. *Fault in Lippmann's Colour Photography.* **O. Wiener.** (Wied. Ann. 69. 2. pp. 488–530, October, 1899.)—The author points out and explains the faults in the pictures produced by the peculiar interference of the rays reflected from the gelatine surface with the rays proceeding from within the gelatine itself. There is always a difference of phase between the surface wave and the wave reflected from Lippmann's first elementary stratum, and this difference of phase displaces the spectrum colours towards the red, and produces wrong colouring. The obvious remedy is to eliminate the surface reflection altogether. This can be done by inserting the finished plate in a bath of benzol, which has about the same refractivity as gelatine, and therefore eliminates the reflection at the surface of the latter. A less circumstantial remedy consists in producing a large difference of path between the surface wave and the first elementary wave, by coating the gelatine with a layer of collodion. If this layer is made of such a thickness as to make the phases of the two waves coincident, very brilliant and true effects are obtained; but that can only happen by a fortunate accident, as the thickness required differs with the colour. About 9 to 13 elementary layers contribute to the reflection of the colours, and each of them is probably about 1·4 $\mu\mu$ thick. The phase displacement of these layers is not zero, as assumed by Lippmann, but may under certain conditions attain a quarter-wave-length. E. E. F.

50. *Electrophotography.* **L. Fomm.** (Wied. Ann. 69. 2. pp. 479–48 October, 1899.)—A study of Lichtenberg figures has led the author to devi a plan for photographing sections of different kinds of wood by simple conta The sections must be thin and smooth. They are covered on one side wi tinfoil, and on the other with a sheet of bromide paper, with the gelatine contact with the wood. A negatively charged metallic point is mounted at distance of 5 cm. from the paper surface. An influence machine produces good impression in about half a minute, showing clearly the cambium rin and medullary rays of the wood. What happens is that the paper negatively charged, and the narrow layer of air between it and the wood filled with photographically active glow-light, which varies in intens according to the nature of the woody substance. The electrophotograph tl obtained is not necessarily similar to an ordinary photograph, since the lij and shade does not depend upon the optical character, but upon the physi or chemical structure of the surface. Thus the medullary rays of oak co

out bright, those of beech dark, though optically they are both bright. The reason is that the medullary rays of oak contain much starch, those of beech but little. E. E. F.

51. *Action of Coloured Light on Silkworms.* **C. Flammarion.** (Comptes Rendus, 129. pp. 398–401, August 14, 1899.)—The maximum production of silk takes place in white light, and the next in the purple of the red end of the spectrum, while there is minimum production under the blue rays. The rays between the lines A and E are the most beneficial. These rays encourage the production of female worms, and also the fertility of the latter. Blue rays produce 63 per cent. of males. The number of eggs laid by females reared in the "warm" rays is double that laid by females under the influence of blue light. E. E. F.

52. *Polarisation in Twisted Media.* **A. W. Ewell.** (Amer. Journ. Sci. 8. pp. 89–100, August, 1899.)—Glass is an unsatisfactory material for experiments on the rotatory polarisation of light in twisted media, since it breaks easily and usually shows double refraction, so that observations are difficult. Agar-agar, gum sandarach, gum arabic, Burgundy pitch, borax, glass and gelatine were carefully tried, but gelatine alone was found satisfactory.

Square glass plates were cemented to the ends of moderately heavy but soft rubber tubes a few centimetres long, and 12 mm. external diameter. Gelatine was reduced to a jelly by adding a suitable quantity of water, with gentle heat, and poured into these tubes through a slit in the side and allowed to cool. One of these square glass caps was placed in a square aperture at one end of a rigid frame. Over the other glass plate was slipped a circular wooden disc with an opening in the centre slightly larger than the glass cap. The jelly tubes were twisted by turning this wooden disc in the frame.

The observations with jelly, corroborated by a few experiments with glass, demonstrate that tension produces rotatory polarisation, the rotation of the plane being opposite to the twist, and a function of the twist of a degree higher than the first. E. E. F.

53. *Achromatic Polarisation and Differential Double Refraction.* **D. B. Brace.** (Phil. Mag. 48. pp. 345–360, October, 1899.)—If a ray of light polarised at 45° to the principal axes of a crystalline plate pass normally through it, the relative retardation of the components will be proportional to the thickness and to the difference in the refractive indices. In most crystals the differential double refraction in the visible spectrum is normal, and the relative retardation increases with the frequency, depending on the crystal. By crossing several such plates the difference in the resultant retardation for adjacent parts of the spectrum might be made a minimum.

The object of this investigation was to determine whether such minima existed and what orders would give the best results. Of the crystals examined, namely, Iceland spar, quartz, selenite mica, and aragonite, all were found to give more or less perfect achromatism through the greater part of the visible spectrum. The results are given of the comparisons of right- and left-handed quartz (the *differential* double refraction being the same whether the *quartz be right- or left-handed*), of selenite and left-handed *quartz, of mica and left-handed quartz,* of mica and selenite, of Iceland spar and *left-handed quartz,* and of aragonite and left-handed quartz. For

example, the ratio of the orders of mica to selenite was found to be 8:7, and of mica to quartz 9:8. The results of the observations show that, with the more available crystals, achromatism cannot be obtained over the entire visible spectrum, but that certain pairs of crystals will achromatise more perfectly than others. Thus better coincidences were obtained with selenite and mica than with quartz and mica. These two pairs are particularly suitable over the others in making compound retardation plates, such as achromatic quarter-wave plates, and the orders used are comparatively low.

J. J. S.

54. *Spectra of Krypton.* **C. Runge.** (Astro-Phys. Journ. 10. pp. 73–79, August, 1899.)—Spectroscopically krypton bears a close analogy to argon. Like argon it emits two different line spectra, one with Leyden jar and spark-gap in the secondary circuit of an induction coil, the other without Leyden jar and spark-gap. As in the case of argon this latter spectrum consists on the whole of less refrangible lines, and if it were possible to fill a vacuum tube with pure krypton, the colour of the tube would probably change from yellow to blue, when the Leyden jar and the spark-gap are interposed. But there seem to be no means as yet of getting rid of the admixture of argon.

The author describes an unexplained explosion which takes place when the oxygen is removed from liquid air, and the remaining nitrogen is sparked. Certain carbon bands which remain are identical with those attributed to "metargon." These bands resist even sparking into oxygen over a solution of potash. With low pressure the carbon bands are greatly reduced in intensity. The krypton lines are also weakened, and the lines of the blue spectrum of argon make their appearance. With a Leyden jar and a spark-gap the spectrum of krypton changes as well as the spectrum of argon. The new lines are mostly in the blue part of the spectrum. The author gives a list of 47 krypton lines without a jar and a spark-gap. The strongest are at 4319·76, 4454·07, 4463·82, and 4502·43 A.U. To select the lines due to krypton he compared the photographs with photographs taken some years ago by Paschen and himself of the spectrum of argon. On each of the two plates to be compared he removed the gelatine on one side of a straight line, cutting the lines of the spectrum at right angles. The plates were then laid together in such a manner that the parts where the emulsion was left were in contact along the cut, but on different sides. In this way the plates can be examined under the microscope and the lines that exist only on one of the plates are detected. None of the lines were measured visually.

E. E. F

55. *Spectrum of Radium.* **E. Demarçay.** (Comptes Rendus, 129. pp 716–717, November 6, 1899.)—An account of the photographic spectrum of radium obtained from specimens of barium chloride containing radium The wave-lengths of fifteen of the strongest of the new rays are given many of them are as strong as the strongest of those of barium. All th lines are narrow and sharply defined, and resemble those of barium.

J. J. S

56. *Titanium for Comparison Spectra.* **E. B. Frost.** (Astro-Phys. Journ 10 pp. 207–208, October, 1899.)—The spark spectrum of titanium shows large number of very sharp lines, very uniformly distributed throughout th spectrum from λ 4200 to λ 5000, and free from air lines. The spark pass

much more steadily between titanium electrodes than in the case of iron, and considerably shorter exposures are required—less than ten seconds as the apparatus is usually arranged. The consumption of the element is very slight, and it is only necessary to occasionally brighten up the points of the electrodes. Titanium is, therefore, very useful for comparison spectra, especially in astronomical work. E. E. F.

57. *Diffraction of Röntgen Rays.* **C. H. Wind.** (Wied. Ann. 68. 4. pp. 896–901, August, 1899.)—In further discussion of the interpretation of Fomm's experiment (see 1899, Abstract No. 1871), the author denies that it follows, from the low wave-lengths obtained that the rays are really some 3,000 times shorter than those of yellow light. Diffraction images like those obtained can also be produced by proper vibrations of any frequency, even that of ordinary light, if only these vibrations experience quite irregular changes of phase, with intervals between them corresponding to the frequencies resulting from the diffraction phenomena. They may also be produced by any very irregular process within the source, provided the radiation emitted by any point leads, for any larger interval from zero time to the time 2T, to a series like

$$\frac{1}{T}\sum_{n=1}^{n=inf}\left(A_n \sin\frac{n\pi t}{T}+B_n \cos\frac{n\pi t}{T}\right)$$

where the coefficients A_n and B_n are of the same order of magnitude over the whole range of wave-lengths in question, and only decrease to any considerable extent outside that range. E. E. F.

58. *Glass and Röntgen Rays.* **O. Schott.** (Zeitschr. Instrumentenk., Beib. 18. pp. 111–113, July 1, 1899.)—Glass containing soda (natron) 10 per cent., boracic acid 30, alumina 20, arsenic acid 0·4, and silicic acid 39·6 per cent., is exceedingly transparent to Röntgen rays. Platinum wire put through glass makes a tight joint if the exceedingly fine rift produced by inequalities in the expansion be filled by heavy mineral oil drawn in by capillary imbibition, so long as the rift is caused by the glass having a smaller coefficient of expansion than the glass. A. D.

59. *Diffusion of Ions into Gases.* **J. S. Townsend.** (Roy. Soc., Proc. 65. pp. 192–196, July, 1899.)—Loss of conductivity by Röntgenised gas left to itself is due partly to recombination of positive and negative ions, partly to discharge of charged ions by the walls of the vessel. Consider the ions as being equivalent to a separate gas. The charged ions diffusing to the (metallic) walls of the vessel may be regarded as absorbed by them, as moisture is when a gas bubbles through sulphuric acid. If the Röntgenised gas be passed through metallic tubing this action at the bounding surface is great in comparison with the effect of recombination. The problem thus becomes, in order to obtain the coefficient of diffusion, to find, if a small quantity of gas A is mixed with another gas B, and the mixture passed along a tube the sides of which completely absorb A, what quantity of gas A emerges from the tube along with B. The result is: if k be the coefficient of diffusion of the ions *into the gas B; a* the radius of the tube and z its length*; V the mean velocity of the gas (i.e.,* total volume flowing in time

$t = \pi a^2 Vt$); that the ratio of the number of ions emerging from the tube to those entering it is—

$$R = 4\left\{0\cdot1952\epsilon^{-\frac{7\cdot313kz}{2a^2v}} + 0\cdot0243\epsilon^{-\frac{44\cdot5kz}{2a^2v}} + \&c.\right\}$$

the terms of the series beyond the second being too small to be taken into consideration. The coefficients of diffusion of ions differ from gas to gas, and are not the same in moist and dry gases. For dry air they are 0·0274 for positive ions and 0·042 for negative; for moist air 0·032 positive, 0·035 negative. For oxygen, dry, 0·025 positive, 0·0396 negative; moist, 0·0288 positive, 0·0358 negative. For carbonic acid, dry, 0·023 positive, 0·026 negative; moist, 0·0245 positive, 0·0255 negative. For hydrogen, dry, 0·123 positive, 0·190 negative; moist, 0·128 positive, 0·142 negative.

One of the equations of motion—

$$\frac{1}{\kappa}pu = -\frac{dp}{dx} + nXe,$$

where p is the pressure of the ions, e the charge on each ion, u the velocity of the ions under electric force X, and n the number of ions per cub. cm., gives when we take n and p as N and P ($=10^6$) at atmospheric pressure and the potential gradient 1 volt per cm. (*i.e.*, $X = \frac{1}{300}$ in c.g.s. measure), and take $dp/dx = 0$, the result that—

$$Ne = 3x \cdot 10^8 u/k.$$

This gives the following value of Ne for dry gases: air, $1\cdot35 \times 10^{10}$; oxygen, $1\cdot25 \times 10^{10}$; carbonic acid, $1\cdot30 \times 10^{10}$; hydrogen, $1\cdot00 \times 10^{10}$. These figures are in accord with electrolytic results: the conclusion is that the charges on the ions produced by Röntgen rays in air, oxygen, carbonic acid, and hydrogen are all the same, and are equal to the charge on the hydrogen ion in a liquid electrolyte. Taking J. J. Thomson's value (6×10^{-10}) for the charge on the ion in Röntgenised hydrogen or oxygen, we have 2×10^{19} molecules in a cub. cm. of a gas, and the weight of a molecule of hydrogen equal to $4\cdot5 \times 10^{-24}$ gramme. In order to show that the charge on the positive ion is equal to the charge on the negative ion, the ratio of the coefficients of diffusion must be shown to be equal to the ratio of the velocities. In spite of some results to the contrary, this seems probable, the results in question being possibly affected by moisture. A. D.

60. *Influence of Becquerel Rays upon Spark-gaps.* **J. Elster** and **H. Geitel.** (Wied. Ann. 69. 3. pp. 673–675, November, 1899.)—Proceeding from the known influence of ultra-violet light and of electric waves upon the form of discharge in a spark-gap, the authors studied the effect of the double ionisation known to be due to the Becquerel rays. A spark-gap 1 cm. wide, between a positive knob and a negative disc, was exposed to a radium preparation. The sparks or brushes of the discharge were immediately converted into a glow discharge, a violet glow surrounding the knob. The former discharge form was re-established on intercepting the Becquerel rays by means of a plate of lead. When the disc was made of semi-conducting cardboard instead of metal the gap became so sensitive that the radium preparation affected the discharge at a distance of over a metre. Unlike the case of short-wave light, it is indifferent whether the electrodes be polished or amalgamated or not, but in both cases it is found that negative brushes cannot be extinguished. Röntgen rays, like intermittent ultra-violet light, produce no effect, probably owing to their intermittence. E. E. F.

61. *Magnetic Deflection of Becquerel Rays.* **F. Giesel.** (Wied. Ann. 69. 4. pp. 834–836, December, 1899.)—The author has succeeded in producing some striking negatives showing the deflection of Becquerel rays in a magnetic field. He took flat pole-pieces and laid a sensitive plate upon them, film downwards. He placed a fresh and very active polonium preparation below the film and in contact with it. On development, the blackening was found to be concentrated just in contact with the substance and along a zone on one side of the line joining the poles. The exposure was about five minutes. Between the black patch and the black zone there were a number of dark traces resembling wavy hair attached to the central patch as a head and extending into the dark zone. These traces are very difficult to account for. They somewhat resemble the ramifications seen in some Lichtenberg figures. The same effects are obtained with radium preparations, though not in the same strength as in the case of polonium. The magnetic deflection of Becquerel rays must now be considered as proved. Elster and Geitel's negative result was obtained with a vacuum, and not in the open air.

E. E. F.

62. *Radioactivity from Becquerel Rays.* **P. Curie** and **Mme. M. P. Curie.** (Comptes Rendus, 129. pp. 714–716, November 6, 1899.)—The authors find that the rays emitted by strongly radioactive substances (such as polonium and radium) when they act on inactive substances are able to communicate radioactivity to them, and that this induced radioactivity persists for a considerable time. The radioactive matter is placed in the form of powder on a horizontal plate, and above this, at the distance of a few millimetres, the plate experimented upon is fixed. After exposure the radioactivity of the upper plate is determined by the conductivity which it communicates to air. The acquired radioactivity increases with the time of exposure, but seems to tend towards a limit. It is retained by the substance for many days, but gradually disappears. To produce the effects it is necessary to use strongly radioactive substances. Those employed were from 5,000 to 50,000 times more active than uranium, and the induced activities observed immediately after the exposure then varied from 1 to 50 times that of uranium. These activities were reduced to the tenth of their original value two or three hours after the removal of the influence. In the various substances examined (such as zinc, aluminium, lead, paper, &c.) no differences in the order of magnitude of the induced radioactivities were observed, all the substances behaved in a similar way.

The effects seem not to be due to traces of radioactive matter carried under the form of vapour or dust on to the exposed plate, but an *induced radioactivity* appears to exist, which is a sort of secondary radiation due to the rays of Becquerel.

J. J. S.

63. *Atomic Weight of the Metal in Radioactive Chloride of Barium.* **Mme. S. Curie.** (Comptes Rendus, 129. pp. 760–762, November 13, 1899.)—The salts of barium directly extracted from uranium minerals are distinguished from the barium salts obtained from other minerals by their radioactivity. Examined by the spectroscope they give the rays of barium, and the atomic weight of barium is found for the metal. By suitable methods of fractionating the radioactivity may be concentrated so as to obtain products more and more active. On examining these products M. Demarçay has found the appearance of a new spectrum which in the last products attains the same intensity as that of barium. The author has determined the atomic weight of

the metal in these successive products and finds that it is greater in the case of radioactive barium than in that of ordinary barium, and that this difference increases with the activity of the product. The experiments along with those of Demarçay seem to show the actual existence of the hypothetical element *radium* possessing a higher atomic weight than that of barium. J. J. S.

64. *Diffraction of Röntgen Rays.* **C. H. Wind.** (Wied. Ann. 69. 1. p. 327, September, 1899.)—The equations in the last paper on the subject (see 1900, Abstract No. 57) are corrected in one place. The correction does not, however, influence the main conclusion. E. E. F.

65. *Thorium Radiation.* **R. B. Owens.** (Phil. Mag. 48. pp. 360–387, October, 1899.)—An account is given of an investigation of the nature of the radiation given off by thorium. The methods used are similar to those employed by Rutherford in his experiments on uranium radiation. (See 1899, Abstract No. 1001.) Thorium radiation resembles in its behaviour that given off by uranium, but there are indications that thorium radiation is not confined to so few distinct types, if indeed the number is limited. If Röntgen rays and the radiations from uranium, &c., are disturbances in the ether occasioned by the internal motion of certain constituent parts of the atom, as has been suggested, it might be expected that such disturbances would shade off with some degree of regularity from a more intense to a less intense kind, and such seems to be the case with thorium.

The principal points treated in the paper are: (1) Conditions affecting the constancy of the radiation. (2) The relation between current and electromotive force. (3) Comparison of radiations from different salts. (4) Types of radiation. (5) Selective absorption. (6) Effect of suspended particles in the path of the conduction-current. (7) Variation of conduction-current with pressure of gas. (8) Absorption of radiations in air. The thorium salts used were the oxide, sulphate, and nitrate. J. J. S.

66. *Phosphorescence at Low Temperatures.* **C. C. Trowbridge.** (Science, 10. pp. 245–249, August 25, 1899.)—Many of the experiments described are the same as those of A. and L. Lumière (see 1899, Abstract No. 551). The author arrives at some general conclusions :—

A. That the reduction of the temperature of a phosphorescing substance is accompanied by a corresponding decrease in the phosphorescent discharge

B. That very low temperatures cause phosphorescence to linger long enough to be readily observed in a number of substances that are not visibly phosphorescent at normal and high temperatures.

C. That the production of phosphorescence in a phosphorescent substance is less when excitation occurs at low temperatures than when it takes place at high temperatures, other conditions being the same.

A number of common substances show marked phosphorescence when reduced to the temperature of liquid air and then exposed to strong light besides ivory and paper there are gum arabic, cotton-wool, starch, white glue celluloid, and kid-skin. E. E. F

REFERENCE.

67. *New Speculum Metals.* **L. Mach and V. Schumann.** (Akad. Wiss. *Wien.*, S. ber. 108. pp. 135–162, 1899.)—Full discussion of the preparation and optic advantages of a series of alloys of magnesium and aluminium in atomic proportion A. I

HEAT.

68. *The Energy Theory.* **J. E. Trevor.** (Journ. Phys. Chem. 3. pp. 339–348, June, 1899.)—The author defines "work equivalents," *e.g.*, increase of kinetic energy in a given mass, increase of temperature in a substance measured by the quantity of work which would have to be expended to produce the change, and so on. Then the algebraic sum of all the work and work equivalents added to any given system of bodies during any change of the system is the change of a definite function of the variables defining the state of the system, and that function is defined to be the energy.

The equation of energy in its differential form is—

$$dE = \Sigma d'W + \Sigma d'E,$$

in which every $d'W$ denotes work, and every $d'E$ work equivalent, and it is important to distinguish between them. The notation d' is used to denote that the quantity to which it is prefixed is not a function of the state variables.

Potential is then defined. For instance, work spent in transferring a quantity of heat in the ordinary thermodynamic system from a lower to a higher temperature is an increase of potential.

The present paper is mainly occupied with a generalisation of the Carnot cycle. A continuation is promised. S. H. B.

69. *Theorems of Robin and of Moutier.* **P. Saurel.** (Journ. Phys. Chem. 3. pp. 548–550, November, 1899.)—The author gives an expression for any virtual change in a system containing n components in r phases, which results in—

$$\delta\phi = V dp - H dT,$$

in which p denotes pressure, V volume, T absolute temperature, and H entropy, and ϕ is the total thermodynamic potential.

Dealing with a univariant system, he points out that it admits of a continuous series of states of equilibrium, all having the same values of ϕ, but in which V and H are different. It follows from the above equation that for any virtual change with constant T, if V increases ϕ diminishes and *vice versâ*. This is Robin's theorem. For any virtual change with constant p, if H increases ϕ diminishes and *vice versâ*. This is Moutier's theorem. Finally he deduces the formula of Clapeyron and Clausius. S. H. B.

70. *Heat of Fusion of Naphthylamine and Diphenylamine.* **J. M. Stillmann and R. E. Swain.** (Zeitschr. Phys. Chem. 29. pp. 705–710, September 15, 1899.)—The following results are obtained :—

Diphenylamine.	Specific heat, liquid	= 0·4712
	„ „ solid	= 0·4058
	Heat of fusion	= 23·97
Naphthylamine.	Specific heat, liquid	= 0·4105
	„ „ solid	= 0·3747
	Heat of fusion	= 25·59

The molecular depressions of the freezing-point, calculated by means of van't Hoff's formula from these figures, are: Diphenylamine 88·8, naphthylamine 81·2, the results of freezing-point determinations being 88 and 78 respectively. The great discrepancy which formerly existed was therefore due to the inaccuracy of Battelli's determinations of the latent heats of fusion. T. E.

71. *Thermal Coefficients.* **J. E. Trevor.** (Journ. Phys. Chem. 3. pp. 523–547, November, 1899.)—In the thermodynamic system we have usually four variables dealt with, namely, p the pressure, v the volume, θ the absolute temperature, and η the entropy, of which only two are independent, and any two may be taken as independent. This gives rise to four equations of the form $f(x, y, z)=0$, in which x, y, z may stand for any three of the four, and the form of f depends on the three chosen.

Four fundamental functions are dealt with, namely, E the energy, which, using v and η for independent variables, gives rise to—

$$dE=-p\,dv+\theta\,d\eta\,;$$
$$\text{F the free energy}=E-\theta\eta\,;$$
$$\text{G the heat function}=E+pv\,;$$
$$\text{H the entropy function}=E+pv-\theta\eta.$$

The author deduces—

$$\begin{aligned}\theta\,d\eta&=B_\theta dv+C_v\,d\theta\\&=A_\theta dp+C_p d\theta\\&=B_p dv+A_v\,dp\end{aligned}$$

in which the coefficients A, B, C, are to be determined. This form the author recommends as having marked advantage over that commonly employed. He determines these coefficients in terms of E, F, G, H, and their differential coefficients with regard to p, v, θ, η, giving rise to 22 equations, including six known forms.

Finally he gives three dynamical equations—

$$\begin{aligned}-p\,dv&=I_\eta dp+K_p d\eta\\&=I_\theta dp+J_p d\theta\\&=J_\eta d\theta+K_\theta d\eta,\end{aligned}$$

and these coefficients, I, J, K, also can be expressed in terms of the fundamental functions and their derivatives.

The result is that all the derivatives of the entropy, *e.g.*, $\frac{d\eta}{dp}$ (v constant), &c., can be expressed in terms of the fundamental functions and their derivatives. The same is true of v. There remain to be added $\frac{dp}{d\theta}$ (v constant) and $\frac{dp}{d\theta}$ (η constant). S. H. B.

72. *Thermodynamics.* **K. Wesendonck.** (Wied. Ann. 69. 4. pp. 809–833 December, 1899.)—Although the majority of workers completely admit the validity of the second law of thermodynamics, some serious criticisms have been advanced against it. The author discusses several of the points at issue, without, however, having recourse to the so-called kinetic theory of heat. He points out that the main principles of Clausius are still valid, and that his inequality must be regarded as the most general form of the second law.

E. E. F.

73. *Perfect Radiator.* **W. E. Wilson.** (Astro-Phys. Journ. 10. pp. 80–86, August, 1899.)—The author measured the radiation at various temperatures of an "Ideally black body" in the shape of a uniformly heated enclosure with a small opening. He found Stefan's law of radiation, $R=aT^4$, very closely [illegible]d. An estimate of the sun's effective temperature, based upon this law, [illegible] at 11,800°. E. E. F.

74. *Solid Carbonic Acid.* **H. du Bois** and **A. P. Wills.** (Deutsch. Phys. Gesell., Verh. 1. pp. 168–169, June 30, 1899.)—Since the triple point of carbonic acid lies at $-57°$ and at a pressure of over 5 atmospheres, the vapour-pressure curve under less than the atmosphere can only be that of the solid snow. The authors have studied this curve, and found considerable deviations from Faraday's approximate figures. The following temperatures were obtained at various pressures (in mm. of mercury):—

P	5	40	110	225
θ	$-124°$	$-112°$	$-102°$	$-95°$
P	510	638	760	885
θ	$85°$	$-81·5°$	$-79·2°$	$-77°$

The coefficient $dP/d\theta$ is about half that of boiling oxygen, and double that of boiling water. As regards the practical applications of carbonic acid snow, it appears that by exhaustion to 5 mm. a temperature as low as $-125°$ can be produced. Much lower temperatures can probably be attained by further exhaustion. The resistance of a bismuth spiral at $-180°$ is 230 times its value at 0° outside a magnetic field. E. E. F.

75. *Influence of Molecular Volume on Gaseous Viscosity.* **G. Jäger.** (Akad. Wiss. Wien., S. ber. 108. pp. 447–455, 1899.)—In previous papers the author has obtained for gases the formulæ—

$$pv=\mathrm{RT}\left\{1+4\beta(1+\tfrac{5}{8}\beta+\ldots)\right\};$$
$$\lambda=\lambda_0/(1+\tfrac{5}{8}\beta+\ldots),$$

where λ denotes the mean free path and $\beta=b/v$ is the ratio of the molecular and specific volumes: these give for the viscosity—

$$\eta=\eta_o\left\{(1+\tfrac{5}{8}\beta+\ldots)^{-1}+4\beta\right\},$$

where η_o is the viscosity for small densities. Thus for moderate densities the the viscosity is $\eta_o(1+\frac{3}{8}\beta)$, but for the liquid state it approximates to $4\eta_o$ [if $1+\frac{5}{8}\beta+\ldots$ becomes large when $v=b$].

The molecular forces are further assumed to affect this formula by a factor $1+k\nu$, where ν is the proportion of the molecules that have combined together, which with van der Waals' formula is approximately represented by—

$$2a/v\mathrm{RT}\ [=27\beta\mathrm{T}_c/4\mathrm{T}]:$$

thus—

$$\eta=\eta_o\left\{1+\tfrac{3}{8}(1+9k\mathrm{T}_c/2\mathrm{T})\beta\right\}.$$

The velocity of a colliding molecule is then considered, as to whether it is determined by the layer in which the molecule's centre was, or by that in which its point of collision was, at the previous encounter; and it is concluded that in the usual formula for the viscosity λ should be increased to the ratio 5 : 4, so that—

$$\eta_o=\tfrac{5}{12}\rho c\lambda,$$

where c is the velocity of mean square. R. E. B.

76. *Specific Heat of Non-electrolytic Solutions.* **W. F. Magie.** (Phys. Rev. 9. pp. 65–85, August, 1899.)—By an approximate consideration of a simple cycle the author shows that (a) the osmotic pressure of a solution is equal to its latent heat of expansion, and (b) the specific heats of the solvent and of the solute in a solution are constant at all concentrations, if (i.) the

[illegible] proportional to the absolute [illegible] pressure when some of the [illegible] negligible. (ii.) the specific heats of [illegible] temperature. (iv.) the change [illegible] in change of temperature [illegible] conclusion is justi[illegible] is the heat capacity of the [illegible]

[illegible] were determined by experimental [illegible] and the corresponding [illegible] of equal amounts of [illegible] similar calorimeters and being [illegible] passed through coils of equal [illegible] cane sugar, dextrose, glycerine, [illegible] and glycerine in aniline, and [illegible] is applicable to their [illegible] water and of glycerine in ethyl [illegible] appears that the apparent molecular [illegible] glycerine in water in the ratio [illegible] ethyl alcohol from that [illegible] while the specific heat of water in [illegible] Thus the [illegible] is not so entirely indepen[illegible] solvent. R. E. B.

[illegible] **K. Tsuruta.** (Phil. Mag. [illegible] September 1899.)—Clausius found that this quantity at [illegible] for carbon disulphide, [illegible] it is negative. The quantity in [illegible] formula—

$$h = \frac{dr}{dT} - \frac{r}{T} + H$$

where r = latent heat of evaporation and H is the specific heat of saturated [illegible] and assumes that—

$$H = C_p$$

the specific heat of the liquid under constant pressure. The author shows that the latter assumption is justified, but that—from the measurements of Ramsay and Young and Battelli—the value of dr/dT is a much larger negative quantity than Clausius supposed, and hence the value of h at temperatures between $-20°$ and $+25°$ is probably negative. From Ramsay and Young's measurements the author finds—

$$r = 98{\cdot}27 - 0{\cdot}256t$$

R. A. L.

[illegible] *Specific Heat of Gases.* **A. Leduc.** (Annal. Chim. Phys. 17. pp. 484–510, August, 1899.)—The author discusses the two specific heats of a gas in connection with the mechanical equivalent of heat. Owing to the uncertainty of the data available it is difficult to formulate general laws, but the following two principles can be very satisfactorily demonstrated :—

1. The molecular capacity for heat at constant volume is the same for gases of the same valency taken in corresponding states.

2. This capacity for heat is proportional to the number of atoms contained in the molecule.

The conception of corresponding states is likely to throw further light on the specific heats of gases.

The ratio γ decreases with rising temperature and with falling pressure. The velocity of sound increases by about 0·08 per cent. as the pressure rises from 1 to 2 atmospheres. Witkowski found an increase of 7 per cent. between 1 and 120 atmospheres, and the increase between 1 and 2 atmospheres is, according to him, 0·072 per cent., or slightly less than the above value.

E. E. F.

79. *Constants of Hexamethylene.* **S. Young** and **E. C. Fortey.** (Chem. Soc., Journ. 75. and 76. pp. 873–883, September, 1899.)—The authors have measured the vapour pressures, specific volumes, and critical constants of hexamethylene by the same methods as for isopentane (see 1899, Abstract No. 1680). The liquid was eventually purified by partially freezing it in solid carbon dioxide and ether and filtering through platinum wire gauze. Among the results are—

Melting-point	4·7°	Critical temperature	280·0°
Boiling-point (760 mm.)	80·9°	„ pressure (mm.)...	30252
Specific gravity 0°/4° ...	0·79675	„ volume	3·659

Its properties appear to be intermediate between benzene and normal hexane. The ratio of actual to theoretical density at the critical point is low (3·703 against 3·77 for the average of normal liquids). R. A. L.

80. *Critical State.* **C. Dieterici.** (Wied. Ann. 69. 3. pp. 685–705, November, 1899.)—The author proves that van der Waals' original equation of condition is not consistent with actual observations of the critical volume, not even if the additions and extensions proposed by Jäger, Boltzmann, and van der Waals himself are taken into consideration. But the theory and observations can be brought into harmony by substituting a new law for van der Waals' cohesive pressure. The author assumes that the work expended against cohesion is proportional to the pressure. But this assumption, though consistent with facts, lacks theoretical explanation. The fundamental conceptions of van der Waals may also be introduced into the formulæ of the kinetic theory. Another set of equations of condition are thus obtained, which are also quite consistent with the results of observation. The author has put these two methods side by side. Subsequent work will have to show which of the two forms corresponds most closely to actual facts observed under varied conditions. E. E. F.

81. *Properties of Partially Miscible Liquids.* **R. A. Lehfeldt.** (Phil. Mag. 47. pp. 284–296, 1899.)—The pair chosen for investigation were phenol and water, mixtures of which are homogeneous in any proportions below 70° C. Four different arrangements of apparatus were employed, one of which is very suitable for indicating differences of pressure; and these all gave results in practical agreement. Curves are drawn showing the variation of the vapour-pressure with the percentage of phenol in the mixture at 50°, 75°, and 90° C., and a curve also showing the variation of the concentration with the temperature under the pressure of 1 atmosphere. A noteworthy result observed is that phenol *added to water up to 60 or 70 per cent. makes practically no difference to the vapour-pressure of* the water, so that within this *long range the isothermals are very flat.* (See 1899, Abstract No. 61.) R. E. B.

[illegible]

R.

[illegible] Callendar. [illegible] Ma[illegible]

[illegible] Associati[illegible] [illegible] standard of reference [illegible] scale defined by [illegible] constant [illegible] and 100° C. re[illegible] B.P. of sulphur [illegible] This scale is subject to far les[illegible] temperatures, than that practically obtained [illegible] constructed and used as the history o[illegible] it is easily and accurately r[illegible]

ducible and is a very close approximation to the Kelvin absolute scale, its exact relationship to which would be a subject for future experiment.

The necessity for adopting a *practical* standard is first shown, and the grounds stated for the selection of *platinum* as standard : the expansion, calorimetric, thermoelectric, and resistance-methods of employing platinum are then compared to the distinct advantage of the last from every point of view, and the construction and standardising of resistance-thermometers are discussed. A strong plea for the employment of constant pressure instead of constant volume in gas-thermometers is then put forward, and for the use of helium in place of hydrogen or nitrogen, and the correction for expansion of the bulb of such thermometers is discussed.

The following selected fusing- and boiling-points on the proposed B.A. scale are given :—

Tin	F.P.	231·9	Aniline	B.P.	184·1
Bismuth	„	269·2	Naphthalene	„	218·0
Cadmium	„	320·7	Benzophenone	„	305·8
Lead	„	327·7	Mercury	„	356·7
Zinc	„	419·0	Sulphur	„	444·5
Antimony	„	629·5	Cadmium	„	756
Aluminium	„	654·5	Zinc	„	916

R. E. B.

86. *Gas Thermometer for High Temperatures.* **L. Holborn** and **A. L. Day.** (Amer. Journ. Sci. 8. pp. 165–193, September, 1899.)—Up to 500° C. bulbs of Jena borosilicate glass No. 59[III] with enclosed hydrogen prove exceedingly satisfactory, no appreciable changes in the zero point being shown after repeated heatings. Porcelain bulbs, whether glazed inside and out or outside only, and whether containing hydrogen or nitrogen, were unsatisfactory, as their zero point rose slightly after each heating and the expansion-coefficient between 0° and 100° often exhibited unaccountable variations. These were employed up to 1100°. Platin-iridium bulbs filled with chemically pure nitrogen, which were tested up to 1300°, were found to be entirely satisfactory when heated electrically ; they showed a constancy of the zero point and of the expansion-coefficient which was equalled only by that of glass bulbs at comparatively low temperatures. For this result however electrical heating is requisite, since, if combustion products are present, they rapidly pass through the wall of the bulb, even against an excess of pressure : this heating was effected by passing an electric current through a coil of nickel wire wound upon a thin tube of porcelain or clay.

For comparison of the readings of the gas thermometers a platinum platin-rhodium thermo-element was also employed in every experiment.

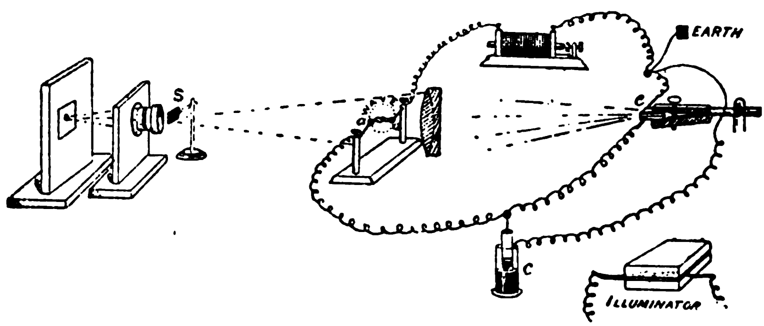
The paper contains full details of the methods employed, the baths used and the electric ovens constructed. For the latter the wire was wound logarithmically upon the tubes and not uniformly, so as to prevent variations of temperature within them. The temperatures given with a porcelain bulb are always somewhat higher than those with a platin-iridium bulb, the difference amounting to 8·5° at 1150°. R. E. B.

87. *Measurement of Extreme Temperatures.* **H. L. Callendar.** (Nature, 59. pp. 494–497, and 519–522, 1899.)—A Royal Institution lecture giving a history of pyrometric methods, and an outline of proposed new forms of air thermometers, especially one depending on measurement of transpiration by a Wheatstone's bridge method. R. A. L.

SOUND.

88. *Notes of Highest Pitch.* **R. Koenig.** (Wied. Ann. 69. 3. pp. 626–660, November, and 69. 4. pp. 721–738, December, 1899.)—Kundt's dust figures offer an admirable means of accurately determining the pitches of tuning-forks of pitches high above the limits of audibility. The fork c^7, placed at the mouth of a tube with a length of some 95 semi-wave-lengths, and a diameter of about one semi-wave-length (11 mm.) gives very clearly defined figures. The method is available up to f^9 (90,000 complete vibrations per second), a pitch which is over an octave above the extreme limit of audibility. The method of beats ceases to be practicably available two octaves below that limit. The author also studied the various means of producing notes of the highest pitches. Rods vibrating transversely are less disturbed by the method of fixture than any other class of bodies. The audibility of their notes is about the same as that of tuning-fork notes. Longitudinally vibrating rods are not available beyond a^5, since their transverse tones then begin to interfere. The notes of vibrating plates are too feeble for determining the limit of audibility, and are greatly influenced by the manner of fixture. The notes of high organ-pipes greatly depend upon the strength of the blast, but they obey Cavaillé Coll's law very closely. They show further that the audibility of a note depends largely upon its duration. Strings and membranes are quite unsuitable for producing high notes. As regards sirens, they are excellent for producing strong notes of high pitch, but care must be taken to have the blast strong enough to enable it to traverse the holes in the disc. E. E. F.

89. *Photography of Sound Waves.* **R. W. Wood.** (Phil. Mag. 48. pp. 218–227, August, 1899.)—The waves are photographed by a method based upon Toepler's "Schlieren" or striæ. A linear source of light, *e*, is obtained by allowing sparks from an induction coil to play between magnesium ribbons pressed between glass plates. This source is focussed upon a slit *s*



which stands in front of a camera focussed upon the spark-gap *aa*. The waves produced by the spark alter the density of the air, and certain densities hinder the rays from passing the slit. There will therefore be dark lines on the screen corresponding to those densities. A great variety of sound experiments may be made with this apparatus and a good lens, and the laws of reflection and refraction may be illustrated. E. E. F.

90. *Measurement of Sound.* **J. Cauro.** (Journ. de Physique, 8. pp. 483-485, September, 1899.)—To obtain uniform sounds the author adopts two different systems. In the first he employs tubes driven by compressed air enclosed in a steel tube provided with a double Fournier regulator. It gives a remarkably steady sound, but has the inconvenience of a movement of translation of the air. In another arrangement he uses an electrically driven Mercadier tuning-fork acting upon a resonance box, and only uses the sound proceeding from the box (the fork being screened). To measure the intensity of the sound he observes the vibrations produced by it in a microscope. A piece of goldbeater's skin treated with caoutchouc is mounted on a small drum. A very light disc of glass is stuck in the centre. It carries a light glass rod to the end of which is attached a piece of perforated tinfoil. A source of light is placed behind the perforation and observed with the micrometer-microscope. The motion is easily measured, and may be analysed stroboscopically. A test with Lisajous's figures shows that the disc vibrates in unison with the source, and not in one of the harmonics. E. E. F.

91. *Vibration of Telephone Diaphragms.* **J. Cauro.** (Journ. de Physique, 8. pp. 485-486, September, 1899.)—Newton's rings are used for studying the vibrations of the disc. The rings are blurred as soon as the telephone is acting. A stroboscopic analysis restores them, and their changes may be made as slow as required. The phenomenon is, however, too minute for studying the elements of the sounds or the relation between loudness and current intensity. E. E. F.

92. *Longitudinal Vibrations of Caoutchouc Fibres.* **V. von Lang.** (Wied. Ann. 69. 4. pp. 804-808, December, 1899.)—Next to the transverse vibrations (see 1899, Abstract No. 1697) the longitudinal vibrations of caoutchouc are of interest. They were determined under various tensions by comparing the pitches of the transverse (n) and the longitudinal (n') notes. The ratio of these is within the limits chosen independent of the length. It may be represented by the formula—

$$\frac{n'}{n}=\sqrt{\frac{l\,\sigma}{\lambda\,s}}$$

where s is the load and λ is the elongation of the length l, produced by a small additional weight σ. E. E. F.

ELECTRICITY.

93. *Elementary Law of Electrodynamics.* **F. Kerntler.** (Journ. de Physique, 8. pp. 556–562, October, 1899, and Écl. Électr. 21. pp. 153–156, October 28, 1899.)—The author discusses the formula of Ampère expressing the elementary law of electrodynamics, and brings forward alternative formulæ. The possibility of the establishment by experiment of the electrodynamic law proposed by the author is considered. J. J. S.

94. *Electromagnetic Fallacy.* **E. Lecher.** (Wied. Ann. 69. 4. pp. 781–787, December, 1899.)—The author criticises König's conclusions from his experiment on the continuous rotation of a magnetic pole about a conductor traversed by an electric current. He maintains that a magnetic pole does not rotate along the lines of force due to a current, and that all alleged rotations of this kind are due to secondary causes. He proves this by a simple modification of the so-called fundamental experiment, and points out that all theoretical explanations offered neglect the presence of the other pole. E. E. F.

95. *Electrostatic and Electromagnetic Induction.* **W. de Nikolaïève.** (Écl. Électr. 20. pp. 10–14, July 8th, and pp. 53–58, July 15, 1899.)—This is an academical paper upon electrostatic and electromagnetic induction. It does not lay claim to originality, but it reviews some of the theories of Quincke, Poynting, and Ewing. The basis of the argument is that the transformation of lines of force and the change of tensions and pressures in the passage from one medium (air) to another (iron) is sufficient, without further assumption, to explain all the effects of magnetic induction and the movements of paramagnetic and diamagnetic bodies in a magnetic field. R. A.

96. *Electromagnetic Theory.* **P. S. Wedell-Wedellsborg.** (Zeitschr. Phys. Chem. 29. pp. 494–497, 1899.)—According to Maxwell's theory a stationary electric current gives rise in its neighbourhood to two fields of force —a magnetic field which depends on the strength of the current, and an electric field which depends on the electromotive force. J. J. Thomson is quoted as saying that a stationary current can flow through a long cylindrical conductor of finite section without causing on the surface of the conductor any superficial distribution.

The writer replies to A. Scheye and discusses these theories. He contends that Maxwell's theory leads to inconsistencies. He contends also that to Faraday, not to Maxwell, is due the conception of light being an electromagnetic phenomenon, and considers that Faraday's conception of ether agrees better with aberration phenomena than Maxwell's.

Reference is also made to Ostwald's theory, according to which the sun radiates energy only to colder bodies, and this he says agrees with Faraday's conception of ether and also with some views of J. J. Thomson. S. H. B.

97. *Ohm's Law.* **R. Mewes.** (Elektrochem. Ztschr. 6. pp. 155–158, November, 1899.)—In the treatises "Physik des Aethers" and "Licht, Elektrizitats—und X—Strahlen" the author has dealt with a dynamical theory of the ether explaining among other things thermoelectric phenomena in metals. [illegible]e present paper contains an explanation of Ohm's law in the light of the [illegible]e theory. J. B. H.

98. *Origin of Frictional Electrification.* **C. Christiansen.** (Wied. Ann. 69. 3. pp. 661–672, November, 1899.)—This is the author's fourth communication on the subject. He studied the difference of potential jets of mercury and of zinc amalgam or other amalgam falling side by side through dry or moist oxygen. A mercury jet was surrounded by 12 jets of the amalgam, containing very little of the foreign metal—say 0·1 per cent. The rate of efflux of the amalgam jet was about 2 m. per second, and as the unbroken mercury jet was 18 mm. long, the amalgam opposite the end of the mercury jet had been exposed to the oxygen for about 0·01 second at the point of measurement. As long as the oxygen was somewhat moist, the normal difference of potential of 0·88 volt was indicated between the amalgam and the mercury. But when the moisture was gradually reduced the difference of potential steadily decreased, and finally was reversed in sign at a point where the vapour pressure was about 0·5 mm. This indicates that the amalgam forms a hydrate in moist air and an oxide in dry air. Magnesium amalgam shows a higher difference of potential, both positive and negative. Cadmium amalgam shows about the same as zinc, and lead amalgam less. The negative values of the differences of potential are very indefinite, as it is extremely difficult to employ absolutely dry oxygen. E. E. F.

99. *Electric Figures.* **P. de Heen.** (Comptes Rendus, 129. pp. 717-719, November 6, 1899.)—When an electrified plate of resin is sprinkled with powdered sulphur Lichtenberg's figures are obtained. If around such an electrified plate there be arranged centres of disturbance of the ether, such as flames or electric tufts proceeding from points placed in communication with a coil, the effect is exactly as if the electric energy was driven back by each of these sources and as if they emitted a peculiar wind. Also the electricity disposes itself along the geometrical figures which would be got on projecting on to a plane liquid jets, which on extending themselves into sheets produce the well-known figures. If two foci of projection are used a straight line results, three foci will produce three straight lines meeting in a point, jets arranged in the form of a square will produce squares, when in hexagonal form, triangles. In general the figure obtained may be expressed thus: the geometrical locus is formed of points at equal distance from two foci, the common distance being less to every other focus.

The figures are obtained in a few moments on placing above an electrified plate a series of gas-jets very small and arranged like the jets of water referred to above. The effect is as if these sources gave out an ethereal breath or wind, which on meeting the sheet of resin would carry away the electric energy as a puff of wind carries away dust. Analogous effects may be obtained by using the rays given out by air which has been submitted to the action of Röntgen rays. J. J. S.

100. *Charge of Arc Light Vapours.* **C. Chéneveau.** (Écl. Électr. 20. pp. 401–404, September 16, 1899.)—A vertical "arc" is made to play between a cylinder of one metal and a tube of the same or another metal mounted above it and concentric with it. The vapours from the arc mount upwards through the tube and are led into a Faraday cylinder connected with a quadrant electrometer. The latter always shows a deflection, which usually persists for some time after the arc has been interrupted. When the cylinder is the positive pole the charge indicated is negative and *vice versâ.* The author supposes that the positive pole attracts the negative ions in the vapour, and sends them into the cylinder in numbers exceeding the positive

ions. He proposes to try the experiment of separating the constituents of an ionised vapour by an ordinary electrostatic field. The present experiments were made with copper, zinc, brass, carbon, and mercury. E. E. F.

101. *Electrostatic Rotations.* **R. Arnò.** (Accad. Lincei, Atti, 8. pp. 167–168, September 17, 1899.)—A horizontal metallic plate is divided into three equal sectors, each of which is placed in connection with one terminal of a three-phase circuit. A paraffined cardboard disc is mounted on a point 9 mm. above the metal plate, the latter being 12 cm. in diameter. On working the circuit with an effective difference of potential of 3,000 volts between one terminal and the next, the cardboard disc is set into very rapid rotation. E. E. F.

102. *Moving Bodies in an Electric Field.* **A. Heydweiller.** (Wied. Ann. 69. 3. pp. 531–575, November, 1899.)—If a sphere rotates uniformly in a medium of different conductivity subject to electric stress, a couple acts upon the sphere tending to stop or to accelerate its motion, accordingly as the conductivity of the medium is very small or very large in comparison with that of the sphere. The author has repeated the experiments of Quincke, Arnò, Threlfall, and others made in this connection. He finds that the phenomena in air are complicated by its dielectric conductivity. This conductivity depends upon the field intensity on the one hand and upon the density on the other hand, increasing with increasing field intensity and with decreasing density. A maximum is reached at a pressure of about 0·005 mm of mercury. The conductivity may, according to these conditions, be greater or less than that of a glass sphere or plate suspended in it, and the rotation or oscillations observed will vary accordingly. The author applies this observation to the motion of celestial bodies, which may be regarded as conducting spheres suspended in a non-conducting medium strained by a feeble electrostatic field. He shows that if the earth's potential was 10^7 as at present, or somewhat higher, say 10^{10} electrostatic units, for 100 billion years the field thus created would account for the stoppage of the moon's rotation without having to call in a supposed tidal action. E. E. F.

103. *Brush Discharge in a Magnetic Field.* **M. Toepler.** (Wied. Ann. 69. pp. 680–684, November, 1899.)—Every discharge in the open air is more or less influenced by a magnetic field. The effect may be produced in a peculiarly striking way by producing a negative "brush discharge arc" between a blunt brass point and a slate, and introducing a high water-resistance in the circuit. The discharge is directed between the pole-pieces of an electromagnet. The magnetic field has the effect of crowding the stratifications together, and also of displacing them laterally with respect to each other. An unstable brush discharge is converted into a spark discharge by the magnetic field. E. E.

104. *Ions in the Electric Wind.* **A. P. Chattock.** (Phil. Mag. pp. 401–420, November, 1899. Portion read at Bristol Meeting of the British Association, 1898.)—When an electric discharge passes continuously through the air between a point and a plate an increase of pressure is experienced *on the side of* the plate nearest the point. This pressure is given by *equation*

$$V = Cz/(P - \pi)$$

where V is the velocity of the ions in unit electrostatic field, C is the curr

passing between the point and the plate, z the distance from the point to the plate, P the total increase of pressure on the plate (due partly to impact of ions themselves and partly to the drag of the ions on the air), and π is the pressure due to the impact of ions alone. All these quantities may be experimentally measured except V, which is therefore determined: π is obtained on the assumption that in the air at ordinary pressure the ions give up the greater part of their momentum very near the point, and so a curve of P plotted with z as variable should be a straight line cutting the axis of P in π. The total pressure P is experimentally determined here by plotting the pressures on the plate at different distances from the foot of the perpendicular from the point. A small hole in the centre of the plate allows the pressure at that point to be measured on a manometer, a metal tube being soldered to the back of the plate and surrounding the hole, and connected by india-rubber tubing with the manometer. The point is moved parallel to the plate and the pressures corresponding to its different positions are read on the manometer and then plotted. The integration of the curve gives the total pressure P. The current from the point to the plate is measured on a galvanometer and is always kept constant. Plotting the values of P for different values of z gives a straight line cutting the axis of P in π. In the experiments the strength of the field was practically uniform everywhere except close to the point. (In some experiments the point had a guard ring surrounding it and in electrical contact with it.) This was shown by plotting the difference of potential between plate and point with z as abscissæ; the result being two straight lines, one for + discharge and the other for − discharge.

The velocities calculated from the results of the experiments are—

$$V + = 336 \text{ cm/sec.}$$
$$V - = 489 \text{ cm/sec.}$$

Another method of experimenting is described, in which the plate is replaced by a thin ring, and the point and ring are placed coaxially in a wide glass tube closed at both ends. Two side tubes at the two ends communicate with the two limbs of a manometer which registers the difference of pressure when the discharge takes place: z is varied by moving the ring along the axis of the tube. In this case

$$P = pa + p'$$

where p is the difference of pressure measured on the gauge, a the area of cross-section of the wide glass tube, and p' that portion of the pressure stopped by the ring.

The mean values obtained for the velocities are—

$V + = 413$ cm/sec. in unit E.S. field
$V - = 540$ „ „ „

The other points dealt with in the paper are (1) the relation between the velocity of the ions and that of the wind; (2) the spread of the current between point and plate; (3) the mass of the ions. J. B. H.

105. *Electric Discharge by Light.* **O. Knoblauch.** (Zeitschr. Phys. Chem. 29. pp. 527–545, July 28, 1899.)—The cause of the loss of a negative charge from some bodies when light is allowed to fall on their surfaces is here investigated. The experimental method adopted is that which was used by Elster and Geitel and by others in their experiments on the same phenomena. About sixty different organic and inorganic compounds were experimented

on, and the results are given in tabular form in the paper. The substances were not chosen at random, many of them being taken because of the effect of light on their chemical constitution.

The results may be best summarised on the theory of oxidation and charged ions which the author accepts. Reducing agents and bodies not fully oxidised when illuminated lose their negative charges the most rapidly; oxidising agents and bodies fully oxidised do not lose their negative charge. In no case did any body lose a positive charge any quicker when illuminated than when not. Some bodies which oxidise very readily and do not lose any negative charge, the author considers to be already fully oxidised on the surface. He also applies the theory to those bodies which have their chemical constitution altered by light, *e.g.*, AgCl and AgBr, and considers that the primary action in the chemical change is one of oxidation, the evolution of Cl and Br in the above being secondary phenomena.

The oxidation is considered to be due to the action of the light on the film of condensed gas on the surface of the bodies, causing ionisation of the gas in the film. The traces of this film which always adhere even in atmospheres of other gases account for the loss of negative charge which takes place in these atmospheres.

The author also applies the oxidation theory to explain (1) the positive electrification of an insulated Zn plate when light falls on it, (2) the electric conductivity of air surrounding phosphorus, (3) the effect of a beam of light falling on the kathode in rarefied gases acting as a promoter of discharge, and (4) he criticises adversely the suggestion that the rate of loss of a negative charge by a coloured substance should be a measure of the permanence of the colour in sunlight. J. B. H

106. *Explosive Effect of Electrical Discharges.* **J. Trowbridge, T. C McKay,** and **J. C. Howe.** (Phil. Mag. 48. pp. 279–286, September, 1899 Amer. Journ. Sci. 8. pp. 239–244, October, 1899.)—Experiments over wide range of high voltages show that the explosive effect of electric discharges is due to an electrostatic effect rather than to a heat effect that a strong analogy exists between the terminal conditions existing i electrical discharges and those of the electrodes of an ordinary volta cell in respect of an ionisation and electric attraction and repulsion the particles of the air which is, however, a local phenomenon; that tl electric density on the terminals of a condenser is proportional to tl strength of current which the charging battery is capable of producin and that the electrostatic field, diminishing much more rapidly with t distance than the electromagnetic field, doubtless has its energy consum in molecular movements. A.

107. *Cooling in Sparked Air.* **P. Pettinelli.** (N. Cimento, 10. pp. 117–1 August, 1899.)—A thermometer, in air through which a few oscillating spa from a Ruhmkorff coil (2 to 3 cm.) have been passed, takes about o thirtieth less time to cool than it takes in ordinary air. A.

108. *Pressure within the Spark.* **J. F. Mohler.** (Astro-Phys. Journ. pp. 202–206, October, 1899.)—Experiments were made to test the results tained by Haschek and Mache. (See 1899, Abstract No. 1891.) If their res are near the truth the shift of the lines due to pressure should be considerable; indeed, as in many experiments they found a pressure of n than 50 atmospheres, the displacement of the lines should be four or

times the largest displacement found by the authors in previous experiments with the arc, for the displacement due to 1 atmosphere is a measurable quantity with some elements. The author used a 4-inch concave Rowland grating, mounted in the usual way on piers of solid masonry, in a room of nearly constant temperature. Photographs of the spectrum under consideration were taken along with the spectrum of the arc, at atmospheric pressure, for comparison. The results show that there is pressure produced when the spark passes through a medium, but that it is not nearly so great as supposed from the work of Haschek and Mache. The results also show that the amount of pressure varies with the density of the medium surrounding the electrodes, and that the kind of gas does not affect the result. With a medium such as water, 800 times as dense as air, with a small capacity a displacement of about 0·4 Ångström unit would be produced in the iron lines, which is only a little less than the average displacement of the lines obtained by Wilsing. E. E. F.

109. *Rapid Spark-Discharges.* **H. T. Simon.** (Gesell. Wiss. Göttingen, Nachr. Math.-Phys. Klasse, 2. pp. 183–186, 1899.)—A large induction-coil usually gives a crackling, brilliant, zigzag-shaped spark discharge; but when it is provided with a rapid interrupter (*e.g.*, Wehnelt's) the discharge takes the form of a flaring bow which exhibits no zigzags. Instead of crackling it hisses, the colour of the light is changed, and the brilliancy is much diminished. This "flame-bow" can extend much beyond the usual sparking distance of the coil. If the spark-gap is horizontal the flame-bow is bent upwards by the current of warm air which it produces; the length of its path goes on increasing until it breaks off and starts again lower down. If the discharge takes place between two rods inclined to one another so that the distance between them increases upwards, the discharge begins at the bottom and then slides upwards (until the distance is increased four or five times), snaps, and starts again across the shortest path. (This illustrates the action of certain forms of lightning-protector.) If air is blown into such a flame-bow it passes over into the zigzag spark-discharge. Photographs show that the latter consists of separate sparks, each of which has a jagged path. The flame-bow also consists of separate sparks, but all of these have a twisted, wave-like appearance, and each one follows very approximately the path of the spark which precedes it. When photographed on a moving plate the separate spark-paths appear as approximately parallel curves. Thus when the sparks follow each other rapidly enough, each one finds its path prepared by the preceding one. This preparation must be of the nature of a physical change in the air which only lasts for a short time. The author has determined this time photographically, for air at rest and at ordinary pressure. He finds that a spark follows the path of the preceding spark so long as the interval between them does not exceed 0·0028 second; if it exceeds this the spark follows a new zigzag path. Within wide limits this time appears to be independent of the length of the spark-gap and of the material of which the points consist. D. E. J.

110. *Current in Vacuum Tube.* **A. Righi.** (N. Cimento, 10. pp. 112–115, August, 1899.)—If there be in circuit a battery of small storage cells, a tube of rarefied gas with unequal electrodes (say a disc and a point), a sensitive galvanometer, and a high resistance (*column of distilled water*); *and if* the electromotive force of the *battery be only slightly above what is required* in order to send a *current through and light up the vacuum tube; then* it is sufficient to change

the place of the resistance in the circuit in order to modify not only the luminosity of the tube, but also the strength of the current passing through the galvanometer. The explanation suggested is that the current is not really continuous as it appears to be from the apparently continuous luminosity, but is a succession of discharges governed by the dissimilarity between the electrodes. A. D.

111. *Free Electricity on Vacuum Tubes.* **E. Riecke.** (Wied. Ann. 69. 4. pp. 788–800, December, 1899.)—To demonstrate the existence of free electric charges on the surface of vacuum tubes in action, and to study their distribution, the author employs Lichtenberg's figures. He dusts a mixture of sulphur and red lead on to glass, shakes off the mechanically adhering dust, and photographs the resulting figures. The latter differ according to whether the electrodes are put to earth or not. Just opposite the kathode a ring is formed, free from sulphur, and containing within it irregular patches of minium. A ring of red powder is formed where the plane of the kathode cuts the glass, and a cap of red powder surrounds the kathode wire. The remainder of the tube is covered more or less evenly with yellow powder. When the anode is put to earth, the powder arranges itself in bands extending towards the kathode on one side and the spot opposite the kathode on the other side. Metallic objects placed in the path of the rays cast a sharp shadow free from red powder, and sometimes covered with yellow powder. A metallic mirror produces a spot like the kathode, just as if the kathode rays had been regularly reflected. (See 1898, Abstract No. 636.) E. E. F.

112. *Death from Electric Discharges.* **J. L. Prevost** and **F. Battelli.** (Comptes Rendus, 129. pp. 651–654, October 23, 1899.)—Two hundred and seventy experiments were made upon dogs, rabbits, and guineapigs (compare 1899, Abstract No. 651), the animals being inserted in a condenser circuit, charged by a Ruhmkorff, and the electrodes placed in the mouth and rectum respectively. The fatal effect does not depend upon the direction of the current, nor upon the quantity of electricity, but is proportional to the energy (capacity and square of potential difference). The mortality did not further increase when the spark-gap exceeded 15 mm. and the effect is the same for a capacity 1 and a spark-gap of 4 cm., a for a capacity 4 and a gap of 1 cm. On the whole the number of fatal case decreased with increasing weight and age; two consecutive discharges o 1,000 joules did not kill a dog of 7 kg. weight. Quickly consecutive dis charges have an accumulative effect, but are comparatively less fatal tha single discharges. Five phases are distinguished in the effects: gener muscular contraction, convulsions, spasms, general inhibitions of the nervou system, stoppage of heart's action; young guineapigs cannot be revive even after the second phase by artificial respiration. The paper also refe to the fluctuations in the arterial pressure and to anatomical lesion. H. B

113. *New Vacuum Tube Phenomenon.* **C. E. S. Phillips.** (Electricia 43. p. 811, September 29, 1899. Abstract of paper read before the Britis Association at Dover.) The phenomenon is best described in the wor of the original Abstract :—

"The apparatus used in this investigation consisted of an approximate spherical glass bulb, the ends of which were left open for the purpose inserting two soft iron electrodes, half an inch in diameter, through air-tig

flanges which themselves were cemented to the glass. The bulb was about 2¼ inches in diameter, and the electrodes were chosen of a sufficient length to enable them, while almost meeting at the centre of the bulb, to project outwards slightly beyond the rims of the flanges. A side tube was attached for the purpose of connecting the apparatus to a Sprengel air-pump and McLeod vacuum gauge. Two powerful electromagnets were then adjusted, so as to strongly magnetise the electrodes when necessary.

"A low pressure having been produced in the bulb by the action of the air-pump, leading wires were attached to the iron electrodes to enable the discharge from the secondary of an induction coil to be passed through the rarefied gas. Under these conditions the effects produced in the usual glow-discharges by the magnetisation of the electrodes could be conveniently examined. It was seen that at a pressure represented by 0·008 mm. of mercury, and with the discharge just able to pass in the bulb (the magnets meanwhile remaining unexcited), on shutting off the current from the induction coil and completing the magnet circuit, a luminous ring appeared within the bulb in a plane at right angles to the lines of force and in rotation about the magnetic axis. The number of such rings can be varied by special devices, and their brightness largely depends upon the electrostatic condition of the outer surface of the glass bulb. The circumferential speed of the ring or rings rapidly dies down, and the sense of the rotation reverses when the magnetic polarity of the electrodes is reversed. The rings, when once formed, usually last for many seconds, sometimes for a minute; and they momentarily brighten before disappearing, when the electrodes cease to be magnetised. The appearance of the rings is greatly affected by bringing charged bodies up to the outside of the bulb.

"The effect also depends upon the manner of stimulation of the rarefied gas within the bulb. It is necessary to obtain a particular distribution of charged particles in order to get the best results when the magnet is excited. The shape of the magnetic field is also of importance." E. E. F.

114. *Phillips' Rotation Phenomenon.* **Kelvin.** (Electrician, 43. p. 582. August 4, 1899.)—The author seeks the explanation of Phillips's rotating luminous rings in Varley's fundamental discovery of the torrent of negatively electrified particles from the kathode, when an electric current is forced through a somewhat highly exhausted glass vessel. The tendency of this may be to fill the whole space with negatively electrified particles, remaining scattered through the enclosure for some time after the cessation of the discharge. If this is the case, each of these must, during the initiation of the magnetic field, experience an electrostatic force proportional to its distance from the axis of the field, and in a direction perpendicular to the axis. This is just what is required to explain the rotating rings.

E. E. F.

115. *Repulsion of Electrodes in Vacua.* **H. Ebert.** (Deutsch. Phys. Gesell., Verh. 1. pp. 141–144, 1899.)—The repulsion of electrodes in high vacua when under the influence of an alternating discharge is not, as Neesen supposes, due to thermal expansion of the intervening gas, since hot gases ascending between movable plates produce the effect of an attraction. Moreover, the difference of potential *should fall if hot* gases were at work, whereas in reality *it rises. The author attributes the* phenomenon to residual *electrical effects.* E. E. F.

116. *Anode and Kathode Rays.* **A. Battelli** and **L. Magri.** (N. Cimento, 10. pp. 264–268, October, 1899.)—The authors subjected the same highly exhausted tubes to bipolar and unipolar discharges, and formulate the following rules: In every species of tube both anode and kathode rays are generated, the former proceeding from parts at higher potentials, the latter from parts at lower potentials. In the case of bipolar discharges all parts of the tube generate anode rays, except the kathode, which generates kathode rays only. But when only one electrode is connected with the machine, both anode and kathode rays are generated by the electrode connected. This may be shown by deflecting the rays by a magnet, when that portion of them which produces fluorescence of the glass is deflected like kathode rays, while the other, of the violet colour of the anode light, is deflected in the opposite direction. The anode rays have an oxidising action, while the portions of a metallic screen which are impinged upon by the kathode rays are less oxidised, probably owing to a reducing counteraction of the kathode rays. The charges conveyed by the rays generated in unipolar discharges are studied by the authors by means of an ingenious combined vacuum tube and electroscope.

E. E. F.

117. *Velocity of Kathode Rays.* **E. Wiechert.** (Wied. Ann. 69. 4. pp. 739–766, December, 1899.)—The author employs Tesla currents in a Lecher wire system, and starts the emitting and measuring systems by the same spark. The kathode rays produced are deflected by means of a loop in the condenser circuit. The kathode is hollow, and the rays are under ordinary circumstances concentrated on a hole in a diaphragm. When the Lecher system is at work, the beam is periodically deflected, and appears to be split into two beams, marking the two positions of extreme deflection. A small permanent magnet is then placed in such a position that the beam is deflected to begin with, and the hole in the diaphragm corresponds to one of the extreme positions. In this manner a strong and apparently steady beam is made to penetrate the diaphragm whenever the Lecher system is working. After passing for some distance along the tube, the beam passes through another diaphragm, behind which it is caught on the screen. The last portion of the path is surrounded by another deflecting loop. If, therefore, the velocity of the rays is beyond the resources of the arrangement, the deflection will be again in the same direction as in the first loop. But if during its passage along the tube the beam has lost phase with respect to the deflecting oscillation, the beam will show a different deflection, and the periodic change of the deflection along the tube, taken in connection with the known periodicity of the deflecting system, gives complete data for measuring the velocity of the rays.

The observations indicate that this velocity is about one-seventh of the velocity of light. The most probable value for the ratio e/m comes out $1{\cdot}26 \times 10^7$, which is lower than the values hitherto obtained. The moving atomic weight per "electron" appears to be $\frac{1}{1300}$ of the oxygen atom.

E. E.

118. *The Ratio e/m.* **S. Simon.** (Wied. Ann. 69. 3. pp. 589–6 November, 1899.)—In view of the theoretical importance of the ratio the electric charge of a kathode particle to its mass, the author has deavoured to obtain as accurate a value as possible for this ratio. He us Kaufmann's method of transmitting a beam of kathode rays through magnetising coil. The chief matter of importance was the task of det

mining accurately the variation of the magnetic field along the path of the beam, and this was done by means of a specially designed magnetometer. It was important that this field should be as uniform as possible, and that the remainder of the path should be uninfluenced by magnetic forces. For this object the position of the anode and kathode were so chosen that the resultant magnetic effect outside the coil was zero. Three independent measurements were made with different positions of the electrodes. The first and third measurements resulted in a difference of 0·43 per cent., and the first and second in a difference of only 0·1 per cent. The final value of the ratio was $1{\cdot}865 \times 10^7$ c.g.s. units. Kaufmann's corrected value was $1{\cdot}77 \times 10^7$. E. E. F.

119. *High-frequency Glow-light.* **H. Ebert.** (Wied. Ann. 69. 2. pp. 372–397, October, 1899.)—When a high-frequency alternating current, of, say, 1,000 reversals per second, is discharged through a vacuum tube in process of exhaustion, the current intensity increases up to a certain point of exhaustion, and then decreases. At the same time the difference of potential and the energy consumed pass through a minimum. This is explained by the author on the ground of a residual effect of the positive charge in the glow-light, which persists for a short time after the glow has ceased. When different gases are compared, it is seen that the reversal takes place at pressures which are in the same ratio as the mean free paths of the respective gaseous molecules—in other words, where the mean free path has reached a certain value. After that is reached, the charged molecules are no longer capable of exchanging their charges in time for the next discharge. A similar reversal takes place when the pressure is kept constant and the electrodes are moved up to each other. The reversal coincides with the point at which the glow-light layers formed during alternate discharges begin to overlap. When another tube is mounted in parallel, part of the discharge then begins to pass through the second tube. The author has also succeeded in demonstrating a repulsion between the electrodes, due to the fact that the positive charges produced by one anode persist after the other electrode has become an anode. E. E. F.

120. *Positive and Negative Spark-Discharge in Gases.* **E. Warburg.** (Preuss. Akad. Wiss. Berlin., S. ber. 40 pp. 770–778, October 19, 1899.)—It is known that the spark-discharge at a negative potential is generally greater than at an equal positive potential. The effect produced on this phenomenon by the presence of slight impurities in the gases appears to have escaped notice. The author's attention was directed to it in the course of experiments on the spark-discharge in nitrogen at various negative and positive potentials. It was found that with a given negative potential the discharge current diminished with the time. *E.g.*, with a potential of—6,160 volts it diminished, in four minutes from 64·4 to 43·7 micro-amperes; when the apparatus was refilled with fresh nitrogen from the gasometer the current rose again to 62·7 and then diminished as before. Whatever the impurity was which produced this effect, it was not capable of affecting in the same way a positively charged electrode. Thus the currents given for $V = 4{,}850$ were (in micro-amperes): Positive, 2·06 at start and 1·95 next morning; negative, 40 at start and 11·2 next morning. The most likely impurity was oxygen, for although the nitrogen had been purified by potash, sulphuric acid, and phosphorus pentoxide, it had been collected in the gasometer over water, and this water would contain air. It was probable that the negative conductivity would be increased by removal of any oxygen present. It was removed by passing the

gas over copper. As long as the copper remained cold there was no change: on heating it there was a considerable increase in the negative discharge. Some of the results obtained with nitrogen purified in this manner were remarkable; *e.g.*, it was now found that the current at a negative potential of 8,810 was 200 times as strong as that at a positive potential of 5,180 volts.

D. E. J.

121. *Transmission of Hertzian Waves through Liquids.* **E. Branly.** (Comptes Rendus, 129. pp. 672–675, October 30, 1899.)—The liquids examined were contained in a cubical case 60 cm. in the side; in the liquid was immersed a wooden box containing the receiver. In order to reach the receiver the waves had to traverse a stratum of liquid 20 cm. thick. The dimensions were fixed before knowing how high the absorptive power of some of the liquids would prove to be, and it was found necessary to use two different radiators, A and B. A was used for comparing the transparency of air, oil, and water: its induction coil had a sparking distance of 2 cm., and the exciter had an air-gap of 1·2 mm. B was much more powerful, and was used for water and saline solutions: its induction coil had a sparking distance of 20 cm., and a Righi exciter with an oil-gap was used with it. The following numbers give in metres the distances (measured to the face of the case) a which the radiator just ceased to act upon the receiver:—

Radiator A.—Air, 10·3; water from the Vanne, 2·2; air, 9·5; mineral oi (valvoline), 10·5; distilled water, 3; water from the Vanne, 2·6.

Radiator B.—Water from the Vanne, 9·2, 9·5; water containing in 18 litres 1 kgm. of common salt, 0·3; water containing twice as much salt, 0·(The latter number indicates that no effect was produced on the receiver whe the radiator was right up against the face of the case.

The same quantity of sea-water would contain about 5 kgms. of commo salt; apparently a layer of it much less than 20 cm. in thickness would com pletely absorb the waves. Sea-water would appear to stop Hertzian wave more effectually than a wall of cement of the same thickness (and, compare with cement walls, dry stone walls are very transparent).

The sulphates of zinc, sodium, and copper show absorptions which a smaller than that of common salt, but are still comparable with it. D. E.

122. *Behaviour of Vapours towards Tesla Oscillations.* **Kauffman** (Zeitschr. Elektrochem. 6. pp. 87–92, July 27, 1899.)—Vapours behave towar "Tesla oscillations" in much the same way as gases. When a tube containi only nitrobenzene vapour with excess of nitrobenzene is held over a "Tes pole," the vapour (and the vapour only) gives out a pale green light; t liquid does not fluoresce at all. Tubes containing naphthalene give only very feeble bluish-white light. (On the other hand, kathode rays are readi formed in them.) The luminescence is accompanied by decompositic Nitrobenzene becomes visibly brown after its vapour has luminesced for few minutes. Tubes after frequent use do not respond so readily. Naphthale tubes also become brown after frequent use and no longer show kathode ra The effect of increasing the vapour-pressure is examined by placing a tube boiling water; of the two "Tesla poles" one is connected to the water a the other to earth. On touching the tube with the hand the following observed: If it is a nitrobenzene tube its luminescence is greatly reduce only green sparks pass through the vapour. If it is a naphthalene tube exhibits a powerful violet fluorescence, visible at a considerable distan *kathode rays* no longer appear. On replacing the tubes in cold water tl

revert to their original behaviour—green luminescence in the case of nitrobenzene, and faint blue in the case of naphthalene. Thus increase of pressure diminishes the luminescence of some vapours while it greatly increases that of others. Examination of the behaviour of a number of vapours boiling under atmospheric pressure shows that the aromatic compounds luminesce much more strongly than the aliphatic compounds. The luminescence is shown by hydrocarbons, amines, and phenols. It is extremely faint in the case of benzene itself ; much stronger in the case of naphthalene, diphenyl, anthracene, and other compounds containing more than one benzene nucleus. The remainder of the paper is chiefly of interest to the chemist. The author believes that a systematic examination of the behaviour of aromatic compounds may throw much light on their constitution. D. E. J.

123. *Propagation of Electric Oscillations in Dielectrics.* **A. Turpain.** (Comptes Rendus, 129. pp. 670–672, October 30, 1899.)—The results of the experiments made by Arons and Rubens, Cohn and Zeemann, and by Blondlot, can be equally well used to support either Maxwell's theory or Helmholtz's theory as modified by Duhem. The author has recently made experiments, the results of which—after making certain assumptions as to the effects of transversal and longitudinal displacements upon the resonator—are free from this ambiguity. His conclusions are in accordance with the Helmholtz-Duhem theory. D. E. J.

124. *Transference of Electric Waves from one Conductor to another.* **M. G. Gutton.** (Annal. Chim. Phys. 18. pp. 5–75, September, 1899.)—Various arrangements were examined in which waves in one wire induced waves in a neighbouring one. In Part I. the secondary and primary wires lay in the same line, their ends adjacent. These were formed into what were the coatings of a Leyden jar under various conditions. It was proved by numerous experiments that the phase period and damping remained unaltered in the secondary. The phase was ascertained by causing the primary and secondary to act simultaneously on the same resonator, the damping by means of Bjerknès' electrometer method.

In Part II. the primary and secondary wires lay parallel for a short portion of their length. For this purpose the two primary wires carrying the waves from either side of the oscillator were bridged across at their ends, and the secondary wires, also joined across, were placed so that for a short distance they ran close to the primary wires. It was proved by experiment that the direction of the electric force in the secondary system was reversed, a change in phase of half a period. The period and damping, as before, were proved to be unaltered. It was also shown that to get maximum effect in the secondary, the portions of the primary and secondary wires running close together should be $\frac{1}{4}\lambda$ on each side of the point of junction of the primary wires.

In Part III. the position on the primary, where the secondary wires were brought into proximity, was moved away from the end—that is, away from the position where the electric force is a minimum. The ends of the secondary being now disconnected a change in phase of half a period could be obtained, or not, according as the ends of the secondary, where the induction took place, were turned up or down the primary lines.

In Part IV. the lines of force in the neighbourhood of a resonator we experimentally studied by means of a coherer. F. T.

125. *Coherer Repeater.* **G. Dary.** (Électricien, 18. pp. 212–214, September 30, 1899.)—Guarini shields the receiving wire from the effects of his retransmitted signals by a metal sheath on one side. M. O'G.

126. *Measurement of Coherer Currents.* **A. Trowbridge.** (Amer. Journ. Sci. 8. pp. 199–205, September, 1899.)—An electromagnetic disturbance induces a static wave in a conductor whose direction is the same as the lines of electric force from the source of disturbance. This static wave was imitated by a condenser discharge in order to test the relation between the quantity of electricity, its potential, and the amount of cohesion. Marconi's coherer was found to give discordant results, and therefore Branly's type with bicycle balls, 9·5 mm. diameter in a glass tube was used. The resistance was adjusted to 2,000 ohms by pressure. For a constant quantity of electricity the resistance fell more when the potential applied to the coherer was higher, but below a critical potential (8 volts for this particular coherer) it did *not* fall. The potential used on the relay should be kept below this figure. The discharge was aperiodic. Reference is made to Branly (Comptes Rendus, cxi.), Dorn (Wied. Ann. 1. xvi. p. 146), and Aschkinass (Wied Ann. xvi. p. 284). M. O'G

127. *Action of a Coherer.* **R. Malagoli.** (N. Cimento, 10. pp. 279–282 October, 1899.)—Tommasina's discovery of conducting chains among th particles of a coherer may, according to the author, be further illustrated b placing, at the bottom of a beaker filled with petroleum or vaseline oil, metallic disc carrying a layer of brass turnings, surmounted by a sma metallic sphere connected with a feeble influence machine. The first phe nomenon observed is the "electric dance" of the particles discharging th electric charge by convection. On diminishing the distance between th disc and the sphere, a moment arrives at which a number of particles forn themselves into a chain, and a spark proceeds along the chain, welding together, while all the loose particles fall back on to the disc. It is clear th the rate of oxidation of a metal has less influence upon the behaviour of th chain than has its fusibility. The dimensions of the particles will also hav an important influence, since upon them depends the chance there is of chain being formed. E. E.

128. *Hertzian Waves and Coherers.* **A. Gilardi.** (Elettricità, Milan, 1 pp. 601–604, September 23, 1899.)—Complete interference is not secured Drude's methods, and the series of interference phenomena is irregular. T coherer is not a suitable instrument for exploring maxima and minima. A.

129. *Vacuum Tubes as Wave Detectors.* **A. Righi.** (N. Cimento, 8. pp. 44–49, 1898.)—The author has designed a vacuum tube showing a co tinuous streak of light between the two electrodes, which under the influen of electric waves breaks up into the usual succession of positive strata, da space, and kathode light. The original appearance is restored when t waves cease. The breaking up is accompanied by a lowering of the resistan The author does not give details of the construction of the tube. E. E.

130. *Opacity.* **O. Lodge.** (Phys. Soc., Proc. 16. pp. 343–386, 18 Presidential address to the Physical Society.)—In this address the author d cusses opacity from the point of view of the electromagnetic theory of lig By experiments in inductive telegraphy, the question was suggested how

intervening layers of moderately conducting matter were able to act as a screen preventing the induction sought. The treatment has reference to Maxwell's Electricity and Magnetism (Chapter 20), where for cases of high conductivity he gives the equation $\frac{d^2F}{dx^2}=\frac{4\pi\mu}{\sigma}\frac{dF}{dt}$.

Here F may be any vector representing the amplitude of the disturbance, and σ is the electrical resistance of the medium. The formal solution is—

$$F=\epsilon^{-Qx+ipt}$$

or—

$$F=\epsilon^{-\left(\frac{2\pi\mu p}{\sigma}\right)^{\frac{1}{2}}x}\cos\left\{pt-\left(\frac{2\pi\mu p}{\sigma}\right)^{\frac{1}{2}}x\right\}$$

giving a distorted wave, different wave-lengths travelling with different velocities—known as the diffusion-case.

The author compares this with Fourier's equation of conduction of heat,

$$\frac{d^2\theta}{dx^2}=\frac{cp}{k}\frac{d\theta}{dt},$$

in which cp is capacity for heat and k is heat conductivity. It is pointed out that heat conductivity and electric conductivity play opposite parts in the two cases, and this can only be explained by calling in ether as the universal solvent.

Reference is then made to Whitehead's paper (Phys. Soc. Proc. June, 1897), which was supposed to support the conclusion that the failure to obtain results in some trials of induction signalling at the Goodwin Sands was due to the conductivity of the water mopping up, so to speak, the induced currents. The author quotes and gives *in extenso* a paper of Heaviside's on this question: also he suggests another explanation of his own.

Maxwell's equation for cases where the conductivity of the medium is relatively small is—

$$\frac{d^2F}{dx^2}=\mu K\frac{d^2F}{dt^2}+\frac{4\pi\mu}{\sigma}\frac{dF}{dt},$$

which leads to a solution of the same form as (1), namely, $F=\epsilon^{-Qx+ipt}$, but with a different value of Q.

Maxwell's treatment of this equation is discussed and compared with Heaviside's. For luminous frequency and bad conductors the solution takes the form—

$$F=F_0\epsilon^{-\frac{2\pi\mu v}{\sigma}x}\cos p\left(t-\frac{x}{v}\right),$$

which is the equation applied by Maxwell to calculations of opacity.

The other extreme case, diffusion, is compared with the transmission of slow signals by submarine cables. Dr. Lodge then introduces Heaviside's at present unverified theory of magnetic conductance, and considers its probable effects. Finally two other kinds of opacity are considered, namely, one not connected with conductivity but due to variation of the constants, K, μ. This is an affair of boundaries. Secondly, opacity like (says the author) that of lamp-black, in which the molecules *appear to take up energy* directly and convert it into their own motion. *The author accepts the theory* of Heaviside that a *current along a wire is to be regarded as the* transmission of a wave in the

space surrounding the wire. The opacity of gold leaf is discussed and a method pointed out by which some part of the discrepancy between theory and observation may be removed. Attention is called to a new theory of Heaviside's concerning the reflection of light at the two surfaces of a thin film, and this is discussed with reference to the theories of Drude, J. J. Thomson, and others. Heaviside's notes on electrical waves in sea-water is given in full in the appendix. S. H. B.

131. *Alternate Current Arcs.* (Instit. Elect. Engin., Journ. 28. pp. 455–474, August, 1899.)—This is a discussion on Duddell and Marchant's paper (see 1899, Abstract No. 829).

L. Andrews showed some diagrams from a photographic record of the current curves from two alternators in parallel and the E.M.F. curve from a transformer excited off the 'bus bars.

J. A. Fleming referred to the unidirectional arc between a metal and carbon, and mentioned the close analogy of the experiments he made in 1890. In these, when a single cell and galvanometer were connected between a middle insulated plate and the negative terminal of a glow-lamp, the current could only flow across the vacuous space when the negative pole of the cell was in connection with the hot carbon. He thought that if in the unilateral zinc-carbon arc the metal pole were heated with an oxyhydrogen flame, the arc would no longer be unilateral. With regard to the electrolytic theory of the arc, he assumes that carbon molecules are broken up into ions which are drawn in the opposite direction by the electric force; if they are monatomic metals this process cannot go on. Another thing he found was that there is a distinct lag between the light-curve of the alternating arc and the current; they are not in step with one another.

S. P. Thompson remarked that in the alternating current arc the current does not entirely keep step with the voltage, and asked whether this is due to the arc acting as a self-induction to produce a lag or as a capacity to produce a lead; but by referring to Duddell's diagram he found that there is no lag in a great many cases, that the potential difference-curve starts and ends at absolutely the same place as the current-curve, and yet the arc acts so that in some way or other it is out of phase; so he finally came to the conclusion that both effects in fact occur.

Duddell and **Marchant,** in their reply, said that they attempted to force the current to flow in both directions through the steady metal-carbon arc by increasing the self-induction in series with it and the E.M.F. of the alternator until the instantaneous value of the P.D. tending to force the current from carbon to metal rose to between 500 and 600 volts, but without success. Heating the metal electrode did not destroy the unilateral nature of the arc. While cooling the carbon they found that the maximum instantaneous value of the current was slightly larger when it flowed from the solid carbon to the cooled carbon than when it flowed in the opposite direction. In each experiment they were obliged to regulate the arc length to allow for the consumption of the carbons, but, as long as the conditions of the dynamo and circuit remained the same, it was found that regulation of the arc length so as to keep the P.D. between its terminals constant resulted in constant arc length, as well as constant current and power supplied to the arc. They finally state that the oscillograph, having a periodic time of $\frac{1}{5000}$ to $\frac{1}{1000}$ of a second, can easily be used to record high-speed telegraphic currents if as large as 30 or 40 milliamperes, but cannot be used for telephone currents, as it is not yet sensitive enough. E. C. R.

132. *Exact Capacity of Submarine Cables.* **J. E. Young.** (Instit. Elect. Engin., Journ. 28. pp. 475–489. Discussion pp. 489–508, August, 1899.)—The author discusses the difficulties arising from (1) The insufficient definition of the quantity sought for, which is a function of the time of charge; (2) The difference of rates of absorption of cables and standard condensers; (3) The variation of absorption of both cables and condensers with time and with temperature; and (4) Leakage errors.

A modification of the Thomson test is described. In this both leakage and absorption are balanced by observation and adjustment during charging, absorption in this case being treated as apparent improvement of dielectric resistance, *i.e.*, the condensers are shunted by a resistance which is adjusted till it approximately balances the apparent dielectric resistance of the cable at any time of charge. Thirty seconds is given as a standard time of charge when testing conductor resistance and inductive capacity. In the discussion **W. J. Murphy** remarked that a connection should be established between the sliding index and the point of junction of the condenser and cable; this prevents the condenser taking up the full potential of the battery while the cable potential is being reduced. Another way is to put a resistance across the condenser inversely proportional to the capacities of condenser and cable and to the dielectric resistance of the latter. Temperature does not affect "free charge" capacity. **A. Siemens** claimed that the speed of the Commercial cable of 1894 is superior to that of the Anglo-American by the reduced sponginess or absorptive quality of the dielectric. **C. Bright** wished to have some assurance that speeds are compared when the definiteness of the signals is the same, or with a standard set of instruments and a standard type of signals. He preferred testing a cable for continuity, by capacity measurements to a sealed end. **Taylor**: The practice of calculating the speed of any given cable on the basis of an empirical constant derived from actual observed speeds of some other cable is wrong. The longer the cable the better the speed constant. **A. Dearlove**: A standard time of charge should be adopted. Increasing temperature was found to lower the capacity of guttapercha cores by 0·02 per cent. per degree Fahr. **Murphy**: The capacity test should be taken when the curve of electrification of a cable becomes sensibly horizontal. An eleven-strand cable clearly increases the self-induction of the cable, and the Telegraph Construction Company's taped core will do so still more. A standard time is unnecessary. M. O'G.

133. *Dielectric Constant in Solid and Liquid States.* **R. Abegg** and **W. Seitz.** (Zeitschr. Phys. Chem. 29. pp. 491–493, July 28, 1899.)—The object of these experiments was to observe the changes which take place in the value of the dielectric constant of a crystalline solid as it gradually cools in the liquid state and then slowly crystallises.

The solid experimented upon was p-Azoxyanisol. This solid melts at about 95° to a viscous opaque liquid which gradually becomes more transparent as the temperature rises until, at 134°, it is perfectly clear and transparent. The dielectric constant of the liquid above 134° is fairly constant, about 4·0; then, as the temperature falls below 134°, the dielectric constant slowly rises until, at 95°, it is 4·3. At this temperature (at which the crystallisation begins) a great change takes place, the dielectric constant falling very rapidly as the liquid crystallises, until when all is solid at about 80° the constant is 2·3. J. B. H.

134. *Dielectric Constant of Stretched Glass.* **O. M. Corbino.** (Accad. Lincei Atti, 8. pp. 238–244, November 5, 1899.)—In reply to Ercolini

criticism (see 1899, Abstract No. 464), the author maintains that the dielectric constant of glass does not increase under a pulling stress. The interpretation put by Ercolini upon one of his experiments contradicts the fundamental electrostatical law, that if a conductor A possesses a constant charge at a potential V_1, and another conductor B at potential V_2 entirely surrounds the former, the introduction of any dielectric only reduces the potential of A without affecting that of B. E. E. F.

135. *Temperature-coefficient of Dielectric Constants: Change from Liquid to Solid State.* **R. Abegg** and **W. Seitz.** (Zeitschr. Phys. Chem. 29. pp. 242–248, 1899.)—Abegg's formula $\frac{dD}{dT} = -\frac{1}{190}D$ is found by Nernst's method to give good agreement for the liquid alcohols at temperatures as low as $-140°$, and for nitrobenzene down to $-9°$, in contradiction to the Clausius-Mossotti and Gladstone formulæ. (See also Ratz, *Zeitschr. Phys. Chem.* 19. p. 94, 1896, and Philip, ibid. 24. p. 18, 1897.) On solidification the dielectric constant drops suddenly and enormously.

The increase of viscosity of the alcohols to a glassy solid, which is to the eye a continuous change, is shown by the dielectric constant to be a sharp change of state, the telephone sound becoming uncompensatable and afterwards giving again a minimum in a widely different position. The *visible change* from glass to crystalline solid takes place *without* change of the dielectric constant. B. B. T.

136. *Electrothermal Relations.* **F. Kohlrausch.** (Preuss. Akad. Wiss. Berlin, S.ber. 38. pp. 711–718, July 27, 1899.)—In a previous paper (Pogg. Ann. 156. 601, 1875) the author considered the thermal equilibrium of an electrically heated cylinder on the assumption that the ratio of the electric to the thermal conductivity is constant; that assumption is not, however, justified by experiment, and the present paper is an attempt to consider the problem on a more general basis.

Let the electric potential at a point x, y, z in a uniform medium be v and the temperature at that point u. Let κ be the electric and λ the thermal conductivity of the medium: these quantities being functions of the temperature only. Then, when the stationary condition is reached, the equilibrium in generation and flow of heat is expressed by—

$$o = \kappa\left[\left(\frac{\delta v}{\delta x}\right)^2 + \left(\frac{\delta v}{\delta y}\right)^2 + \left(\frac{\delta v}{\delta z}\right)^2\right] + \frac{\delta}{\delta x}\left(\lambda\frac{\delta u}{\delta x}\right) + \frac{\delta}{\delta y}\left(\lambda\frac{\delta u}{\delta y}\right) + \frac{\delta}{\delta z}\left(\lambda\frac{\delta u}{\delta z}\right) \qquad (1)$$

where the potential is subject to the condition—

$$\frac{\delta^2 v}{\delta x^2} + \frac{\delta^2 v}{\delta y^2} + \frac{\delta^2 v}{\delta z^2} = -\frac{1}{\kappa}\left(\frac{\delta\kappa}{\delta x}\frac{\delta v}{\delta x} + \frac{\delta\kappa}{\delta y}\frac{\delta v}{\delta y} + \frac{\delta\kappa}{\delta z}\frac{\delta v}{\delta z}\right) \qquad (2)$$

(depending on Ohm's law); but as κ and λ depend on the temperature only we may write the total differential coefficients—

$$\frac{d\kappa}{du} = \kappa' \text{ and } \frac{d\lambda}{du} = \lambda'$$

and get—

$$\frac{\delta^2 v}{\delta x^2} + \frac{\delta^2 v}{\delta y^2} + \frac{\delta^2 v}{\delta z^2} = -\frac{\kappa'}{\kappa}\left(\frac{\delta u}{\delta x}\frac{\delta v}{\delta x} + \frac{\delta u}{\delta y}\frac{\delta v}{\delta y} + \frac{\delta u}{\delta z}\frac{\delta v}{\delta z}\right) \qquad (2a)$$

First consider the case of a cylindrical conductor whose end faces are *(different) equipotential* surfaces, and whose sides are both electrically a

thermally isolated. The solution can then be shown to *depend neither on κ nor on λ, but only on the ratio κ/λ.* It is—

$$u = -\tfrac{1}{2}\frac{\kappa}{\lambda}v^2 + Av + A',$$

where A and A′ are constants. Hence by determining the temperatures and potentials at three points A and A′ can be eliminated, and the ratio of conductivities found. This is proposed as a method of measuring the thermal conductivity of a bar in terms of the easily measured electric conductivity, and has been carried out by Jaeger and Diesselhorst (see following Abstract), using such small differences of temperature that κ/λ may be regarded as constant.

Next, if the conductor is of any shape, but is thermally and electrically isolated at all points of its surface except two areas through which the current is supplied, and are consequently two (different) equipotential surfaces, it may be shown that the same solution holds. Hence, if the bar experimented on be not exactly cylindrical and be interrupted by holes in which to place thermocouples and so on, the method will still be exact, provided the temperature and potential be measured at precisely the same point, and that the loss of heat by radiation may be neglected.

It is obvious that the temperature reached by the bar under the above conditions will be the highest to which it can be raised by the given electromotive force. If the ends of the bar are at the same temperature the middle point will be hotter by—

$$\tfrac{1}{8}\frac{(v_1 - v_2)^2}{\sigma}$$

where v_1 v_2 are the potentials of the ends and σ is the mean value of κ/λ. The lowest value of κ/λ is about $6{\cdot}4 \times 10^{-6}$ volts/degree. Hence 0·01 volt potential difference will raise the centre of the bar by 2°.

In considering large differences of temperature we must make an assumption as to the dependence of κ/λ on u. Assuming, with Lorenz, that it is inversely proportional to the absolute temperature, we find that 0·1 volt would give 163° rise of temperature, 1 volt 3,140°. R. A. L.

137. *Conductivity for Heat and Electricity, Heat-Capacity and Thermo-electric Power of Certain Metals.* **W. Jaeger** and **H. Diesselhorst.** (Preuss. Akad. Wiss. Berlin, S.ber. 38. pp. 719-726, July 27, 1899.)—The ratio of the heat conductivity λ to the electric conductivity κ is here investigated, for pure Zn, Sn, Pb, Cu, Cd, Bi, Ni, Al, Ag, Fe, Pt, Pd, Au, and for a steel, cast iron and constantan ($\tfrac{2}{5}$ Ni, $\tfrac{3}{5}$ Cu), by Kohlrausch's method wherein the temperatures V_1, V_2, V_3 and electric potentials v_1, v_2, v_3 at three points of a homogeneous conductor are determined when an electric current is passing through it and the temperatures have become stationary, the theory giving—

$$\frac{\kappa}{\lambda} = \frac{V_1(v_2 - v_3) + V_2(v_3 - v_1) + V_3(v_1 - v_2)}{\tfrac{1}{2}(v_2 - v_3)(v_3 - v_1)(v_1 - v_2)}$$

if there is no loss of heat by external conduction. The substances were taken in the form of cylindrical bars with their ends fastened to thick copper blocks which were screwed into large water baths; the rods were placed axially within a double-walled cylindrical jacket of copper filled with wadding and with water or steam passing between the walls, and the temperatures were measured thermo-electrically. For details the memoir, which is a communication from the Phys.-Tech. Reichsanstalt, must be referred to. For the pı

metals named λ/κ at 18° C. ranges from 0·00000686 for Al to 0·00000962 for Bi, and at 100° from 0·00000844 for Al to 0·00001077 for Bi. The heat capacity and thermo-electric powers were also obtained from the experiments.

R. E. B.

138. *Thermoelectric Theory.* **W. Voigt.** (Wied. Ann. 69. 3. pp. 706–717, November, 1899.)—The author raises some grave objections to Liebenow's theory of thermo-electric and electrothermal phenomena.

The equation—
$$S^2 = \frac{L}{\lambda T}\left(\frac{dT}{ds}\right)^2$$
where L and λ are the thermal and electric conductivities, S the E.M.F., T the temperature, and s the length of the cylinder, is not only faultily derived, but its form shows that the quantity but not the direction of the E.M.F. is indicated. The apparent agreement of Liebenow's theory with observation is no confirmation, since in his practical applications no recourse is had to the novel methods introduced.

E. E. F.

139. *Peltier Effect in a Magnetic Field.* **A. Pochettino.** (Accad. Lincei Atti, 8. pp. 50–57, July 16, 1899.)—In an iron copper couple, the the value of the coefficient of the Peltier effect varies with longitudinal magnetisation, first increasing to a maximum value of 0·008968 in a field of 98 c.g.s. units, then decreasing and passing through its normal value at a field-strength of about 345 units, results which are in accord with Houllevigue's formulæ (Ann. de Chim. et de Phys. (7) vii. p. 495, 1896). The formula derived from Houllevigue's experiments by means of the Thomson equation connecting the Peltier effect with the thermo-electric power between two metals is found to represent the facts only at a field-strength of 700 units. The variations in the Peltier effect are independent of the direction of the magnetisation, so that the magnetising current may be reversed without affecting the result.

A. D.

140. *Investigation of the Microphone.* **J. Cauro.** (Écl. Électr. 19. pp. 295–302, 333–337, and pp. 410–416, 1899.)—A study of the current variations in primary and secondary circuits of the E.M.F. on open and closed circuit, of the energy spent in a telephone, and of the magnitude of the movements of the diaphragm. The instruments selected are described. Alternating potentials were measured by a Curie electrometer (with flat mirror and giving virtual images) used only as an electroscope. Alternate currents were taken by a modified electro-dynamometer by Giltay-Bellati with soft iron needle, used only as a zero instrument. A spiral strip oscillograph which, however, required standardising with an electrometer for each frequency, was used and the movements of the strip in a strong field noted with a microscope. A telephonic relay having only the self-induction capacity and resistance of a short straight wire was made on the basis of the oscillograph. There is practically no limit to the number of such instruments which might be placed on one line without destroying distinctness.

The source of sound was a pipe whose lip was vibrated electrically to avoid any movement of translation of the air. Sound intensity was measured by observing with a microscope the movements of a rubber membrane, and incidentally it is proved that the movements of the membrane are due to the air only. The displacements of microphone and receiver diaphragms were measured by fixing a glass disc to the membranes and utilising Newton's rings

the displacements being suitably slowed down by Lippmann's stroboscope which is explained and illustrated.

Speech consists of a series of musical vowels separated by stoppages (the consonants), which give rise to extra currents more easily audible than the pure musical notes. All measurements were made after the musical note had been established. When the electrometer method was used for current measurement a resistance without self-induction or capacity (see Comptes Rendus, cvii. p. 779, 1889; cxx. p. 308, 1895) was necessary, and the potential difference at the ends of a known resistance gave the effective current. The table of results cannot be abstracted, but the following is an example: With a distance of the pipe from the microphone of 175 mm. through 20 km. of cable with the loudest note which did not produce cracking sounds, the mean receiver voltage was 2·88, the effective voltage was 2·46, the microphone terminal volts were 1·35 mean and 1·28 effective; the current through the microphone at rest was 0·078 amps., the mean current variation was 0·08 and the effective current variation was 0·28 of the microphone current when at rest. It was found that the effective variable current is independent of the pitch, is proportional to the amplitude of vibration of the sound and is about a quarter of the steady current which continues unchanged during transmission. The effective E.M.F. on open circuit varies as the amplitude of sound and inversely as the pitch. Sound is still audible with one-millionth of an ampere in the secondary and this current does not appear to vary with the pitch (ω). It will be seen that various notes are not affected differently by the telephone, and therefore that timbre should not be lost in transmission. This depends on the importance of the self-induction (L) of the usual apparatus whose apparent resistance is $\sqrt{R^2+L^2\omega^2}$, namely, at 600 periods R^2 is about 10^6, whereas $L^2\omega^2$ is about 50×10^6. On a long distance line like Paris-Marseilles the apparent self-induction of both line and insulation is a few hundredths of a henry so that R^2 is of the order 10^6 and $L^2\omega^2$ is 2×10^3. Hence, as far as distortion of sound is concerned, the line acts as a resistance which is not as important as the apparent resistance of the apparatus: the latter depends mainly on the pitch and the self-induction. M. O'G.

141. *Photoelectric Phenomena.* **E. R. v. Schweidler.** (Akad. Wiss. Wien., S.ber. 108. pp. 273–279, 1899.)—According to Stoletow and Branby the photoelectric current increases with increasing potential difference, but more slowly than the latter, and appears to approach an upper limit. On the other hand, Elster and Geitel found a potassium cell behave in just the opposite way; the current increased much more rapidly than the potential difference of the electrodes. Kreusler also found that the photoelectric current increases with very great rapidity in the neighbourhood of the discharge-potential (*i.e.*, the potential at which spark-discharge begins).

The author's experiments confirm Kreusler's results. Although the galvanometer readings are irregular, they show clearly that from a given point onwards the current increases more rapidly than the potential difference of the electrodes. At low pressures this behaviour begins at potentials which are relatively small (compared with the discharge-potential); at atmospheric pressure it only begins in the neighbourhood of the discharge-potential, and is then very rapid. D. E. J.

142. *Measurement of Variable Discharges.* **C. Heinke.** (Wied. Ann. 69. 3. pp. 612–625, November, 1899.)—In addition to the stationary continuc current discharge and the symmetrical alternate current, attention has rec

been directed to the periodically varying discharge produced from continuous currents by the interposition of an interrupter. An elucidation of the detailed process of discharge in this case is very desirable on account of the characteristic relations existing between the current and potential on the one hand and the effective expenditure of energy on the other. The existing measuring instruments and methods are inadequate for dealing with such measurements, as has been shown by the many obscurities still attaching to the action of the Wehnelt interrupter. Instruments containing iron do not give indications independent of the frequency, while those free from iron, like most dynamometers and hot-wire instruments, usually are governed by the square of the quantity to be measured. The author points out that satisfactory results may be arrived at by measuring potential and current simultaneously with galvanometric and "efficiency" instruments, thus splitting them up into a constant term and a periodically variable term. The latter may be replaced by an equivalent sine wave. The total work of the "wave-current" is best measured calorimetrically, by converting the whole energy expended into heat.

E. E. F.

143. *Conductivity, Viscosity, and Pressure.* **G. Tammann.** (Wied. Ann. 69. 4. pp. 767–780, December, 1899.)—The influence of pressure up to 4,000 atmospheres upon conductivity and viscosity was observed in the case of decinormal solutions of sodium chloride and acetic acid respectively. The almost completely ionised chloride solution shows a very different behaviour from the unionised acid. The conductivity increases slowly with the pressure, but passes through a maximum at 2,500 atmospheres, after which it diminishes again. The resistance never descends below 91 per cent. of the original resistance. In the acetic acid solution the resistance decreases continuously and considerably, reaching less than half its original value at 2,500 atmospheres. In the case of the chloride solution, which is nearly completely dissociated, no further pressure can produce much additional dissociation. Hence, by subtracting the change of volume of the solution from the change of resistance under pressure, we obtain practically the change of ionic friction under pressure. The author finds that the curves of ionic friction are the same as the curves of viscosity. E. E. F

144. *Graphical Treatment of Induction Motor Problems.* **W. Baxter, Jr** (Elect. World and Engineer, 34. pp. 490–494, September 30, 1899.)—By mean of polar diagrams the author explains the various actions taking place in a induction motor. A. H

145. *Power in Circuits Supplied with Distorted E.M.F. Waves.* **S. Barnett.** (Elect. World and Engineer, 34. p. 305, August 26, 1899.)—Eac simple harmonic term in the Fourier series representing the E.M.F. wav produces its own wave of current. The total mean power in the circu is equal to the sum of the powers corresponding to the various harmon components of the wave, each of which develops an amount of power whic is not in any way influenced by the presence of the other harmonics. A.

146. *Determination of Ratio of Transformation.* **J. R. Bibbins.** (Ele World and Engineer, 34. p. 376, September 9, 1899.)—The method describ is useful when only a single voltmeter, the range of whose readings cor sponds to the higher of the two voltages, is available. In such cases t instrument would generally be incapable of reading the lower voltage w

any degree of accuracy. The higher P.D. is read first, and then one terminal of the primary winding is joined to one terminal of the secondary, and a reading obtained when the voltmeter is across both windings. The difference between the two readings, divided by the first reading, gives the required ratio of transformation. A. H.

147. *Effect of Pressure on Resistance of Metals.* **S. Lussana.** (N. Cimento, 10. pp. 73–84, August, 1899.)—After referring to the works of former experimenters, the author describes his own researches on the resistance of various metals and alloys when immersed in oil and subjected to pressures up to 1,000 atmospheres. Wires of iron, silver, nickel, lead, copper, platinum, and several alloys were employed, and tables are given showing the resistance of each at various increasing and decreasing pressures. With increasing pressure the resistance diminishes, tending to a minimum value at very high pressures. If sufficient time elapse between the compression and the measurement of the resistance—usually an hour—the curves taken with increasing and diminishing pressures are practically coincident. As in the case of the temperature variation, the coefficient is much smaller for the alloys than for the pure metals. At atmospheric pressures the actual values are: for iron, 38×10^{-7}; copper, 31×10^{-7}; platinum, 24×10^{-7}; lead, 194×10^{-7}; while for manganin, $5{\cdot}6 \times 10^{-7}$; and for brass, $4{\cdot}3 \times 10^{-7}$, per atmosphere of pressure. From a comparison of these with the temperature and volume coefficients the author concludes that the specific resistance of a metal depends not only on the proximity of the molecules, but also on their velocity of vibration.

In addition to the permanent variation of the resistance with altered pressure, a much larger temporary variation was observed, the duration of which depended on the duration of the previous condition of the conductor. When a platinum wire was subjected to a pressure of 500 atmospheres for an hour, and the pressure suddenly removed, the resistance rose to 0·14 per cent. above its normal value, and gradually fell till in forty-five minutes it had assumed a steady condition. If the previous state of the conductor has been of long duration the temporary variation following the change of pressure assumes the form of a very slow and strongly damped oscillation above and below the normal resistance. In the case of a platinum wire which had been subjected to a pressure of 500 atmospheres for twenty-four hours the resistance took three days after the pressure was removed to assume a steady value, executing in that time three oscillations with amplitudes of 0·3 per cent., 0·013 per cent., and 0·006 per cent. of the normal value. L. B.

148. *Control of Sheet-Iron Tests.* **J. Epstein.** (Elektrotechn. Ztschr. 20. p. 590, August 17, 1899.—Report read before the Deutscher Elektrotechniker in Hanover.)—The author urges the importance of establishing standard methods of testing sheet iron for various purposes. (See 1899, Abstract No. 1,572.) A. H.

149. *Piezo-Electricity.* **F. Nachtikal.** (Gesell. Wiss. Göttingen, Nachr. Math.-Phys. Klasse, 1. pp. 109–118, 1899.)—This paper treats of the proportionality between piezoelectric charges and the pressures producing them. The author placed the crystals between two copper plates insulated by ebonite, and piled weights on to a scale attached to the upper plate. The ends of the crystals were covered with tinfoil, and were connected with an electrometer and the earth respectively. The results show that the deviations

from proportionality between the piezoelectric moments and the pressures are quite small. At the higher pressures, quartz shows a deficiency of piezo-electricity charge, while tourmaline shows a slight excess over the expected value. E. E. F.

150. *Wire-resistance Paradox.* **P. Girault.** (Ind. Élect. 8. pp. 413-414, September 25, 1899.)—Consider two metals, having similar physical constants, except as regards resistivity, and let there be two wires made, one from each of the metals, and let the wires be of unequal lengths and diameters, but of equal resistance. The author writes down the equation for the (equal) heat generated in each wire, using the ordinary C^2R formula, R on each side of the equation being expressed in terms of the lengths, diameters, and resistivities. He then substitutes the respective volumes in those expressions. It is thus shown that the diameters and volumes vary directly as the cube roots of the resistivities, and inversely as the diameters of the wires. Hence it appears that by employing a metal of less resistivity a resistance wire may be made of less volume. This "paradox" is explained by the consideration that the volume is in practice determined by the cooling surface—*i.e.*, by the heat lost, and not alone by the heat generated. R. A.

151. *Resistance of Amalgams.* **R. S. Willows.** (Phil. Mag. 48. pp. 433-456, November, 1899.)--The variations of the electric resistance of amalgams of zinc, cadmium, tin, and magnesium with temperature are here experimentally investigated. The results are given in the form of curves, some of which have very peculiar forms, the curve for falling temperature being in some cases quite different from that for rising temperature. This is particularly the case with the zinc amalgams, in which at certain temperatures (depending on the percentage composition of the amalgam) very sharp bends occur in the curves, indicating some rapid changes in the chemical structure of the amalgam. In some of the amalgams these bends occur only where a change of state takes place, but in others they occur where no external change is apparent.

The variations of other physical properties of the amalgams with temperature are also experimentally determined, and, in the case of a zinc amalgam, the time curve of absorption and emission of heat under definite conditions shows steady parts corresponding to the angular bends in the resistance curve.

The author considers also what theoretical structure of the amalgam would give the observed results, and obtains one analogous to that which Guillaume supposes to exist in nickel steel in order to explain its peculiar physical properties. J. B. H

152. *Absolute Determination of the Kilohm.* **A. Guillet.** (Journ. de Physique, 8. pp. 471-477, September, 1899.)—The method of determination is analogous to that due to Lippmann. A Thomson galvanometer is wound differentially. One of the pairs of coils, of resistance G_2 receives per second n discharges of the value q, and the other pair of coils of resistance G_1 compensating current of intensity i. When a balance is obtained the relation—

$$nq = i$$

is satisfied.

Induction being produced in a circuit of resistance r, between two co

B, b of mutual induction M, by the make or break of a current I, we have—

$$q = \frac{MI}{r}$$

Also $I = \frac{V}{R}$ where V is the potential difference between the ends of the resistance R carrying the current I. The compensating circuit is formed by a resistance R, and a variable resistance S as a shunt to the windings G_1, so that putting—

$$R' = R + \frac{S\,G_1}{S + G_1}$$

we get—

$$i = \frac{S}{S + G_1} \cdot \frac{V}{R}$$

and obtain the equation—

$$\frac{nM}{rR} = \frac{S}{S + G_1} \cdot \frac{1}{R'}$$

whence—

$$R = nM\left(1 + \frac{G_1}{S}\right) \cdot \frac{R'}{r} \tag{1}$$

The coils G_1 and G_2, traversed by the same current, do not generally have equal effects on the galvanometer needles, so that equation (1) requires modification. Suppose that—

$$R = pnM\left(1 + \frac{G_1}{S}\right) \cdot \frac{R'}{r} \tag{2}$$

where the value of p depends upon the relative positions of the coils and the needles.

Now interchange the coils G_1 and G_2, and again adjust to equilibrium, obtaining an equation—

$$R = \frac{1}{p} \cdot n'M\left(1 + \frac{G_2}{S_1}\right) \frac{R_1'}{r_1} \tag{3}$$

On multiplying (2) and (3) and putting—

$$\gamma_1 = \frac{G_1}{S}\ ;\ \gamma_2 = \frac{G_2}{S}\ ;\ \lambda = \frac{R'}{r}\ ;\ \lambda_1 = \frac{R_1'}{r'},$$

we get—

$$R = M\sqrt{nn'(1 + \gamma_1)(1 + \gamma_2)\lambda.\lambda_1}.$$

Another correction has yet to be applied. When the inductive circuit is broken the difference of potential V takes a new value V_1. Consequently the compensating current is not constant, it varies very little on account of the small resistance of the battery used.

Let f be the time during which the inductive and compensating circuits are simultaneously active, and let $b = \frac{V_1}{V}$; we can then proceed as if the compensating circuit were subjected to a constant potential difference—

$$e = \left\{ f + b\,(1 - f) \right\} V = \frac{1}{\phi} V \text{ (say).}$$

R is then finally calculated from the formula—

$$R = M\sqrt{nn'(1 + \gamma_1)(1 + \gamma_2)\lambda.\lambda_1} \,.\, \phi.$$

Working on this formula, in which M is wound so as to be easily calculable, the author arrives at 106·2 centimetres of mercury as the value of the ohm.

W. G. R.

153. *Absolute Determination of the Kilohm.* **A. Guillet.** (Écl. Électr. 20. pp. 161–171, August 5; pp. 212–218, August 12; pp. 288–291, August 26; pp. 328–336, September 2; pp. 376–380, September 9, 1899. See also preceding Abstract.)—In this series of articles the author gives a complete historical summary of the methods adopted in the direct absolute determination of the kilohm, paying particular attention to Lippmann's method, upon which his own method is based.

W. G. R.

154. *Measurement of Internal Resistance of Accumulators.* **E. C. Rimington.** (Elect. Rev. 45. pp. 623–624, October 20, 1899.)—A variety of ways are described, all based on a comparison of the potential difference of two similar cells, the one discharging, the other on open circuit or practically so. It is worked out as a condenser, as a differential galvanometer, and as a Wheatstone bridge method; and modifications of the latter are given by means of which errors due to polarisation may be eliminated.

E. J. W

155. *Current Strength in Three-pointed Star Systems.* **A. E. Kennelly** (Elect. World and Engineer, 34. pp. 268–270, August 19, 1899.)—The current strengths in three-pointed star resistance systems are calculated by the method of vectors. The results arrived at are—

$$i_1r_1 = \frac{e_3r_1r_3 - e_2r_1r_2}{r_1r_2 + r_2r_3 + r_3r_1},$$

$$i_2r_2 = \frac{e_1r_1r_2 - e_3r_2r_3}{r_1r_2 + r_2r_3 + r_3r_1},$$

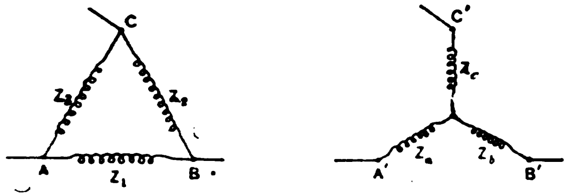
$$i_3r_3 = \frac{e_2r_2r_3 - e_1r_1r_2}{r_1r_2 + r_2r_3 + r_3r_1},$$

where e_1, e_2, e_3 are the E.M.Fs. between the respective pairs of termina r_1, r_2, r_3 the impedances of the three circuits and i_1, i_2, i_3 the currents flowi in them.

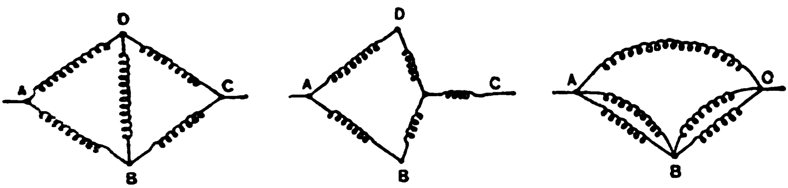
W. G.

156. *Equivalence of Triangles and Stars in Conducting Networks.* **A. Kennelly.** (Elect. World and Engineer, 34. pp. 413–414, September 1899.)—Calculations relating to conducting networks may be frequer simplified by replacing a delta or triangle grouping of conductors betw any three points by a star or Y-grouping, or *vice versâ.* As an example of simplicity which may result from such a substitution, the author consid the case of the Wheatstone's bridge, fig. 3. The calculation of the impeda between the points A and C when the bridge is unbalanced is a comj problem. But if we replace the △ B C D by its equivalent Y, as in fig. 4 if we replace the Y consisting of DA, DB, and DC by its equivalent △, a fig. 5, then the problem is greatly simplified. The following are the l according to which such substitutions have to be effected : (1) The impeda of a Y-branch lying between, or replacing, a pair of delta-sides is equal to product of the impedances of those sides, divided by the impedance of th considered as a simple closed circuit. Thus, if figs. 1 and 2 denote equiva

arrangements, then $Z_c = Z_2Z_3/(Z_1 + Z_2 + Z_3)$, and so on. (2) The admittance of a delta-side corresponding to, or replacing, any two Y-branches is equal to the product of the admittances of those branches, divided by the sum of the admittances of all three branches. If the three conductors contain E.M.Fs., then in replacing a Δ by its equivalent Y the equivalent E.M.Fs. in the Y-branches are determined as follows: Draw the vector E.M.F. diagram of the



FIGS. 1 AND 2.—STANDARD TRIANGLE AND "Y."



FIGS. 3, 4 AND 5.—TRANSFORMATIONS OF WHEATSTONE BRIDGE.

Δ and apply at its corners imaginary masses equal to the admittances of the corresponding Y-branches. Find the centre of gravity of the loaded Δ, and connect it with the corners by straight lines. These lines represent respectively the E.M.Fs. to be inserted in the branches of the Y. Some numerical examples are worked out in illustration of the method. A. H.

157. *Three-voltmeter Method of Power Measurement.* F. **Niethammer.** Elektrotechn. Ztschr. 20. pp. 701–708, October 5, 1899.)—An elaborate criticism of the three-voltmeter method. The author arrives at the conclusion that from every point of view the wattmeter method is superior to the three-voltmeter one, and that there is no longer any justification for the use of the latter method. A. H.

158. *Loop Test on Electric Light Cables.* J. **Wright.** (Elect. Engin. 24. pp. 295–296, September 8, 1899.)—The author uses the Post Office bridge; shows how to adapt a rough slide wire to it of 20-gauge copper, and how to connect the cable when there is an E.M.F. in the fault, as well as other practical details. M. O'G.

159. *Testing Electric Meters and Instruments.* J. **Sahulka.** (Zeitschr. Elektrotechn., Wien. 17. pp. 481–486, September 17th; pp. 491–497, September 24th; pp. 515–518, October 8; and pp. 527–529, October 15, 1899.)—In these articles there is described the establishment of laboratories for the official testing of electric meters, measuring instruments, and small motors by the k.k. Normal-Aichungs-Commission of the Austrian *Ministry of Commerce*, this work being carried out by the author. The author first states the various conditions to be fulfilled by meters—e.g., that they shall not register when no current is passing;

that they shall begin to register with 2 per cent. of their maximum load; that when calibrated at the maximum current, and at 50 per cent. and 2 per cent. of this maximum, the three values of the meter-constant so obtained shall not vary more than ± 4 per cent. of the mean of the three values, this mean value being the one given in the certificate. In Austria the present charge for testing is 1 gulden; in addition 3 kreutzers per hectowatt maximum load is charged for each meter, no difference being made between 1 and 100 meters. If more than 100 meters of the same system are to be calibrated at a time the 3 kreutzers per hectowatt is reduced to 1·5 kreutzers.

The author gives particulars as to the necessary plant, assuming that about 30,000 continuous-current meters, 10,000 alternate-current meters, and 10,000 polyphase-current meters, or other measuring apparatus, are to be calibrated annually.

In the testing of a number of similar continuous-current meters, the series and shunt coils of the meters are separated and the series coils put in series with each other, and with a low-voltage battery (*e.g.*, 10 cells capable of yielding 1,000 amperes arranged in series), whilst the shunt coils are put in parallel with each other and connected with a battery of the desired E.M.F. When meters for three-wire and like systems are to be tested, all the coils which are to be inserted into the same conductor of the system should be connected in series, so that in testing the meter with respect to its behaviour with one-sided loading an interchange of the branch circuits or reversal thereof can be easily carried out. By these means only one source of current is required for the coils carrying the main current or currents, and one for the thin-wire coils. The switch-boards, connecting devices, and methods of testing employed are described in detail with reference to diagrams. The cost of current for meters for measuring small and medium quantities of energy amounts to 3 kreutzers per meter.

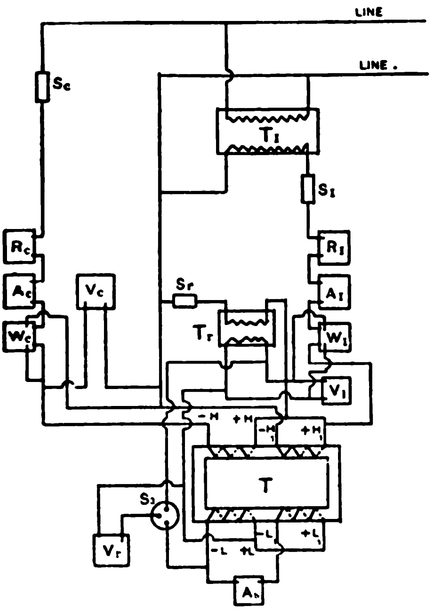
In the testing of alternate-current meters two separate circuits are employed in the same manner as continuous-current meters; one of these circuits carries the main current for the thick-wire coils of the meter, and the other the current for the shunt circuit of the meter. These currents can be obtained by providing the armature of an alternator with a thick and a thin-wire winding which give electromotive forces of the same phase, or the dynamo is provided with a single winding and the two E.M.Fs. required are generated by means of a transformer; examples of these arrangements are described. Alternate-current meters are also to be tested with a difference of phase (up to 60°) between the current and the terminal E.M.F. This difference of phase can be conveniently obtained by introducing a condenser, or a coil having self-induction, into the thin-wire circuit. Details are also given of methods of testing three-phase meters. C. K. F.

160. *Differential Method for Testing a Single Transformer.* **S. E. Johannesen.** (Elect. World and Engineer, 34. pp. 155–157, July 29, 1899.)—This is a method by which a single transformer may be tested under actual working loss conditions with an energy consumption equivalent to the transformer losses alone, and gives directly approximately correct values for iron loss, leakage, copper loss, impedance and regulation.

In the accompanying figure R_1, A_1, W_1, V_1, and R_c, A_c, W_c, V_c, represent respectively resistances, ammeters, wattmeters, and voltmeters for adjusting voltages and currents, and for measuring iron loss and copper loss energy. A_s is an ammeter for measuring low tension current; S_c, S_i, represent respectively switches governing the currents supplying the copper loss

iron loss ; S_r is a switch governing the pressure reducing transformers; ı three-way switch used in connection with the regulation test. T_1 esents a transformer for stepping up the pressure of the current olying the iron loss energy ; T_r is a pressure reducing transformer l in connection with the iron loss and regulation measurements. T is transformer under test.

The figure refers to the case where the energy corresponding to all the s is supplied to one winding only, in this instance the high tension ling. The current supplying the iron loss energy enters the high tension ling through the terminals $+H_1$ and $-H_1$; in other words the iron loss ent is supplied across the terminals of one coil or one-half the high tension ling. The pressure must therefore be adjusted to the normal high tension sure for which that coil is wound.



In this experiment, close switches S_1 and S_r, adjust the pressure by the sistance R_1 with all the instruments in circuit. The idle current or leakage measured by the ammeter A_1 ; the pressure which is reduced by trans-mer T_r, by the voltmeter V_1 ; and the iron loss energy by wattmeter W_1.

The current supplying the copper loss energy enters the high-tension nding through parallel terminals —H and H_1. The low-tension winding is ort circuited through an ammeter A . In reality the low tension coils are nected in parallel. In test, close the switch S_0 and adjust the pressure by e resistance R_c, with all the instruments in circuit. A_c measures the current pplied : the voltmeter, V_c, the pressure ; and the wattmeter, W_c, the energy nsumed. The watts registered on the wattmeter should correspond to the atts of copper loss measured in the ordinary way ; that is, by short circuiting he low tension winding through an ammeter *and supplying* pressure to the igh tension winding until *the full load current passes through* the low tension winding.

W. G. R.

161. *Wehnelt Interrupter.* **E. Rothé.** (Comptes Rendus, 129. pp. 675–677, October 30, 1899.)—When the E.M.F. applied to a Wehnelt interrupter is kept constant, while the resistance of the circuit is varied, a curious phenomenon is observed. The E.M.F. used by the author is 113 volts and the variable resistance consists of two copper plates movable in a column of dilute copper sulphate. When the maximum value is given to the resistance the current is comparatively small (about 4 amperes) but remains constant. The apparatus is now in the electrolytic state and does not act as an interrupter; if an induction coil without the usual break is introduced into the circuit there is not the slightest sparking at the ends of the secondary. If the resistance is gradually reduced, the current increases in accordance with Ohm's law; under the above conditions it thus increases to 11·5 amperes. It then suddenly falls to 2·5 amperes. Thus there is a limiting value for the external resistance at which the state suddenly changes. This new state with a weak current is variable. An ampere-meter in the circuit shows that there are variations in the current; but it is remarkable that once this state is attained, the resistance can be increased or diminished considerably without affecting it. For a given interrupter at a given E.M.F. there is a limiting resistance, such that for every lower resistance the variable state is the only one possible. With higher resistances we may have either the variable or the steady state, according to the way in which the current is started. Hence it is not a matter of indifference whether we close the circuit directly on a large resistance or on a small resistance which is subsequently increased. If the E.M.F. is varied, then to each E.M.F. used there is a corresponding limiting resistance. In the steady, or electrolytic state, bubbles of gas rise rapidly from the platinum wire; in the variable state the bubbles only rise one by one and very regularly.
D. E. J.

162. *Wehnelt Interrupter.* **C. Heinke.** (Elektrotechn. Ztschr. 20. pp. 510–513, July 20, 527–531, July 27, 1899. Report read before the Deutscher Elektrotechniker in Hanover.)—The author treats the Wehnelt interrupter mathematically, taking the general case of an alternate current superposed on a direct current in an electrolytic circuit containing inductive resistance. He also describes an arrangement of apparatus for actual measurements. In conclusion he gives an equation for the work done in such a circuit. R. A.

163. *Wehnelt Interrupter.* **A. G. Rossi.** (Accad. Sci. Torino, Mem. 34. pp. 508–514, 1899.)—The use of a glass tube in Wehnelt's original form may be avoided by soldering the platinum wire to a thick copper wire, and covering the electrolyte with a thick layer of oil. The amount of exposure may be regulated by moving the copper wire up and down, taking care, however, to keep the junction in the oil. E. E. F.

164. *Wehnelt Interrupter.* **E. Ruhmer.** (Elektrotechn. Ztschr. 20. pp. 786–787, November 9, 1899.)—Recent theoretical investigations by Simon show that if T is the periodicity, L the self-induction of the circuit, w the resistance of the interrupter, and E the applied volts—

$$T=\frac{3}{2}\cdot\frac{L}{w}+\frac{K_1 w}{E_2}+K_2$$

re K_1 K_2 are constants. Simon has further shown that this equation gives ts in agreement with experiment; taking cases where w and L are it, and varying E. If the length of platinum immersed is maintained

constant, and the temperature is also kept steady, K_1 K_2, for the same interrupter, do not appreciably alter. The author describes experiments in which E and w kept constant, L being a variable; he shows that the formula for T still holds. R. A.

165. *Mercury Jet Interrupter.* **M. Levy.** (Elektrotechn. Ztschr. 20. pp. 717–718, October 12, 1899.)—The chief advantage of the new interrupter is its great range of adjustment, which not only extends to the number of interruptions per second, but to the fractional value of the interruption in comparison with the closing of the circuit. It consists essentially of a fine jet of mercury forming one contact piece, and a series of teeth cut in a cylindrical surface forming the other contact piece. The cylindrical surface surrounds the jet. Its axis is vertical, and the teeth taper downwards. The jet may be raised or lowered, and thus the ratio of contact to interruption varied between zero and infinity; hence, whatever may be the E.M.F. used, the mean current strength may be brought to the same uniform value. When not in action there is always interruption of the current—a circumstance which is practically very convenient. The ordinary arrangement of the driving mechanism provides for a speed of 800 to 1,000 revolutions per minute, or, since there are twenty-four teeth on the wheel, and the teeth can be separately mounted or omitted, the interruptions per second can be varied from 5 to 400. All the effects of Wehnelt's interrupter can be repeated with the new interrupter. Moreover, any induction coil can be driven direct from the local lighting system without the interposition of resistances, since the mean current strength can be regulated at will. E. E. F.

166. *Vacuum Interrupter.* **J. Elster** and **H. Geitel.** (Wied. Ann. 69. 2. pp. 483–487, October, 1899.)—MacFarlane Moore's "vacuum vibrator," designed to produce an instantaneous interruption, suffers under the drawback that, as soon as the contact point sticks, the current intensity suddenly rises to a high value, and the point melts off and the tube is often destroyed. To avoid this, the authors keep the hammer vibrating by means of a separate electromagnet outside the vacuum tube, actuated by a mercury interrupter of the Roget spiral type. The spiral and the hammer are tuned to unison, but even so the light obtained is somewhat fitful, and less steady, though safer, than the light obtained by Moore. E. E. F.

167. *Oscillographs.* **A. Blondel.** (Ind. Élect. 8. pp. 361–366, August 25, 1899.—The author continues his account of recent progress in oscillography (see 1899, Abstract No. 1510). The double bifilar oscillograph of W. Duddell is described in detail, with illustrations; the principal improvements consist in the use of flat strips in the place of round wires, of a pulley equalising the tension, and of two magnetic fields. A table of the constants of the instrument mentioned in Abstract No. 829 (1899) is given; the natural frequency of vibration is 2,700 per second, and the resistance of each bifilar 0·53 ohm. The arrangement of the apparatus for recording three curves simultaneously is explained, as well as the device, due to Boys, for concentrating the light reflected from the mirror to the screen by means of a cylindrical lens.

The author then points out that the bifilar carrying a mirror can be considered either as two separate threads vibrating transversely, or a combination subjected to torsional vibrations; and taking the latter view, he gives formulæ which he has established for the frequency and sensibility of bifilars of flat and round wire. From these it is deduced that to increase the frequency

the wires must be of square or circular cross-section, and a metal with a low ratio of density to elasticity must be employed; further, to increase the sensibility, the wires must be of light material and as small as possible. These principles were embodied in an experimental oscillograph, which is described in detail, and with which frequencies exceeding 13,000 per second have been obtained, and a sensibility of 0·25 mm. per milliampere at 1 m. distance.

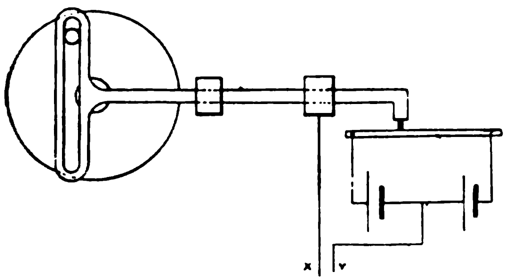
Further refinements of the magnet pole-pieces, to obtain a strong field, are discussed, as applied to an instrument now under construction. The moving rays from the mirrors are received on a revolving mirror; this reflects them upon a ground glass screen and upon a photographic plate, which can be exposed for a suitably short period to obtain a permanent record of the curves. The use of the instrument as a rheograph on Abraham's system is briefly outlined, and the article concludes with a short *résumé* of the best conditions of construction and use of the instruments. A. H. A.

168. *Apparatus for obtaining High Frequencies and Pressures.* **E. Thomson.** (Elect. World and Engineer, 34. pp. 576–578, October 14, 1899. Abstract of paper read before the New York Electrical Society.)—After discussing the various apparatus that have already been devised for obtaining high frequencies and pressures, viz., Rowland's, Tesla's, and Trowbridge's, the author describes his own, which comprises a motor-dynamo, such as is obtained by taking an ordinary continuous-current motor, and tapping the winding so as to obtain alternating currents, *i.e.*, by connecting two of the commutator segments to a pair of insulated rings engaging stationary brushes. The alternating current brushes are connected to the primary winding of a step-up transformer, giving, say, 10,000 to 15,000 volts in the secondary. Driven by the shaft of the machine is a frame of insulating material, having at one side a pair of metal strips which periodically connect the high potential secondary terminals of the step-up transformer to the + and — foils of a set of condensers in parallel; these connections are made over a small spark-gap, in order to avoid noise and friction. The revolving frame is so adjusted, that the charging contact shall only be made at the tops of the waves, and thus a high potential rendered available for charge. By employing the tops of every third wave only, the condenser foils are always given the same polarity. The revolving frame is also provided with a set of connectors whereby, after the charging strips have been withdrawn from proximity to the stationary contacts connected to the condenser foils, these contacts are connected in series, and the terminals can then discharge over a wide air-gap at high potentials, the length of spark being governed by the number of condenser plates, and the potential of the charging current.

An attachment is also provided, whereby Leyden jar batteries can be charged or a stream of thin sparks obtained. This attachment comprises an insulated revolving connector which consists of a pair of balls connected by a wire and serves to bridge a gap of several inches between the end condenser terminal and an insulated ball, the time of making connection coinciding with the series connection of the revolving frame above referred to. The insulated ball is thus synchronously charged, while the opposite terminal of the apparatus may be put to earth. By changing the connections between the collector rings and the primary of the step-up transformer, the ball may be made either positive or negative as desired. C. E.

169. *Production of a Sine E.M.F.* **G. T. Hanchett.** (Amer. Elect. 11. pp. 886–887, August, 1899.)—The author suggests methods of obtai

E.M.Fs. which are accurately represented by sine curves. In one device, a straight conductor is provided which is of uniform high resistance. The ends of this rod are connected to two or more storage cells in series, care being taken that the number of cells be even, and that each cell has the same E.M.F. and interval resistance. Upon the rod (see fig.) which is thus



supplied with current travels a small collecting brush, which is driven by a crank disc and plate in a simple harmonic motion. A lead is brought out at the middle connection of the batteries, and another is connected to the travelling brush. When the machine is set in motion there will exist between these two points an E.M.F. which very approximately follows the sine law.

W. G. R.

170. *Sectorless Wimshurst Machine.* **W. Cotton.** (Electrician, 44. pp. 17–18, October 27, 1899. Abstract from the Bristol Medico-Chirurgical Journal.) —This machine is best described in the words of the original.

"The essential part consists of two parallel circular discs of ordinary window glass, 22 inches in diameter, about $\frac{1}{8}$ of an inch thick, and $\frac{1}{4}$ of an inch apart, varnished with shellac. Being mounted centrally on independent wooden bosses, they can be rotated in opposite directions on a horizontal metallic spindle or axle, which pierces them and is supported at each end by a wooden upright springing vertically from a stout rectangular mahogany base. The lower parts of the two uprights support another horizontal axle parallel to the main one, turned by a handle, with two wooden wheels on it, which by a crossed and an open strap act respectively on the bosses of the glass discs and thus supply the necessary motive power.

"At each end of the main axle where it projects through the supporting upright is metallically connected a movable brass rod, known as the neutralising rod. The rod is bent round at each end towards the surface of the adjacent glass disc, and has jointed to it at each end a straight piece about 4 inches long, radially disposed as regards the glass disc, parallel to its surface and just within the outer margin thereof. Each straight piece has attached to it at equal distances so as lightly to trail upon the surface of the glass three fine wire brushes. Thus we have two neutralising rods, a near one and a far one, each with two straight pieces, and each straight piece has three brushes, i.e., there are twelve neutralising brushes in all.

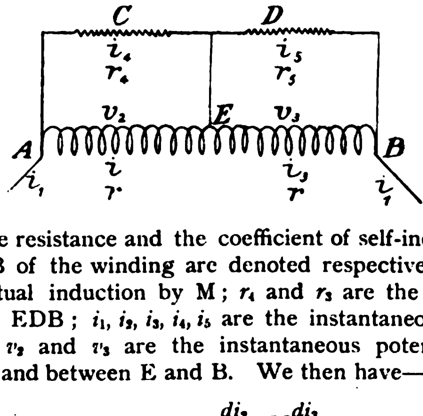
"In practice the sectorless Wimshurst is to be preferred to a sectored one of the same size for five reasons: (1) It is easier to construct and keep in order—it is simpler; (2) it never reverses polarity during running—the other does so occasionally; (3) it has a greater output of electrical energy—the tube lights up better with the same *amount of mechanical* energy expended on the handle; (4) in a sectored Wimshurst, where there is a great resistance in the way, the inner ends of the sectors leak towards the boss, as shown by a

visible brush discharge ; (5) after prolonged use the friction of the brushes on the sectors as they pass leads to the formation of rings of metallic deposit, which break down the insulation."

On the other hand, except under exceptional circumstances, the sectorless Wimshurst is not self-exciting. E. E. F.

171. *Theory of the Potential Divider.* **S. A. Montel.** (Écl. Électr. 20. pp. 298–302, August 26, 1899.)—Under the name "potential divider" the author denotes an apparatus formed by a winding on an iron core, whose ends are connected across alternating current mains and different points of which are joined to various apparatus for use ; these pieces of apparatus are in series with each other, and in parallel with respect to different portions of the winding.

The author treats of the particular case of two groups of apparatus (such as incandescent lamps) without self-induction, each of which derives its potential difference from the potential divider. This arrangement is shown



in the figure. The resistance and the coefficient of self-induction of the two parts AE and EB of the winding are denoted respectively by r and L ; the coefficient of mutual induction by M ; r_4 and r_5 are the resistances of the circuits ACE and EDB ; i_1, i_2, i_3, i_4, i_5 are the instantaneous currents in the various circuits ; v_2 and v_3 are the instantaneous potentional differences between A and E and between E and B. We then have—

$$v_2 = ri_2 + L\frac{di_2}{dt} + M\frac{di_3}{dt}$$

$$v_3 = ri_3 + L\frac{di_3}{dt} + M\frac{di_2}{dt}$$

Also— $$v_2 = i_4 r_4, \quad v_3 = i_5 r_5, \quad v_1 = v_2 + v_3$$

$$i_1 = i_2 + i_4 = i_3 + i_5$$

Putting L=M, we deduce that—

$$\frac{v_2}{v_3} = \frac{r_4 r_5 + r_5 r}{r_4 r_5 + r_4 r}$$

which shows that the ratio of the potential differences depends only on tl ohmic resistances of the circuits. It is further deduced that the curre through the windings is only half that which transverses the circuit D wh the circuit C is short circuited. Also the current traversing the windings is minimum when the circuits C and D are equally loaded. W. G.

172. *Ohmmeter for use on Alternate Current Mains.* (Zeitschr. Elekt techn., Wien. 17. pp. 518–520, October 8, 1899.)—This instrument, which is analogous construction to one designed by Wilkens (see Elektrotechn. Ztsc 1897, p. 748), is constructed by the Allgemeine Elektricitäts-Gesellschaft, Berlin. It comprises a dynamometer, the stationary coil of which is exci

as follows: The primary circuit (A) of a small transformer mounted in the interior of the apparatus, has its terminals connected to the supply mains, the potential difference of which is to be employed in measuring the insulation resistance. This transformer has two secondary coils, of which one (B) is connected directly to the stationary coil of the dynamometer, whilst the circuit of the second secondary coil (C) extends through the movable coil of the dynamometer, the ends being connected to terminals marked respectively, "Earth" and "Installation." When the instrument is connected up for use, the stationary coil of the dynamometer is traversed by a constant current from the secondary coil B, and thus produces a constant alternating magnetic field. If now a current from the secondary coil C passes from the installation to earth, the movable coil of the dynamometer turns and the pointer moves over a scale graduated in ohms. The sensibility of the instrument can be increased by giving the stationary coil as many ampere-turns as possible, which can be easily done by means of the transformer. In order that the measurements shall be made with the normal working potential difference, the coils A and C of the transformer must have the same number of turns. The readings of the instrument are, however, only correct when the potential difference at the supply mains is that for which the instrument is constructed to work. In order to determine whether this potential difference is normal without requiring a special voltmeter, the instrument is adapted to also act as a voltmeter. For this purpose it is only necessary to connect together the terminals "Earth" and "Installation" by means of a wire, and to connect the primary circuit terminals of the transformer to the supply mains as usual. The volts are then read off on a second scale arranged beneath the ohm scale. Examples, illustrated by diagrams, are given in the original paper for explaining methods of using the instrument on three-phase and other systems.

C. K. F.

173. *Alternate Current Ohmmeters.* **G. Benischke.** (Elektrotechn. Ztschr. 20. pp. 410–411, June 8, 1899.)—This is a paper read before the Elektrotechnischen Verein, Berlin, on the methods of measuring the insulation of alternate current networks by employing the normal working voltage. With continuous currents, this test is usually made with an ammeter and voltmeter, which are put successively between each wire of the network when charged to the full working pressure and earth. Similar tests can be made on alternate current circuits by using instruments of the dynamometer type. But in practice the method has several disadvantages; two separate instruments are necessary, and a calculation is required to determine the actual insulation resistance; the current measured may be not only a leakage, but also a capacity current; and if there be a fault on the circuit it may cause a serious short circuit if switched on to the main before being tested.

To obviate these defects an instrument is made by the Allgemeine Elektricitäts-Gesellschaft, consisting of a transformer and wattmeter. The primary of the transformer is connected across the mains. It has two secondaries—one connected across the thin wire coil of the wattmeter; the other, which has the same number of turns and therefore the same voltage as the primary, in series with the moving wattmeter coil between the circuit to be tested and earth. For fixed voltages the instrument is calibrated directly in ohms of insulation resistance. By short circuiting the testing terminals it is available as a voltmeter, for which purpose a second scale is added. The instrument is neat and compact. It is also adapted for attachment to a station switchboard. In high pressure circuits the insulation must

first be determined at the lower voltage to ensure that there is no bad fault, and then tested when under full pressure by means of electrostatic voltmeters. In three-phase networks a fault in the system can be detected by connecting a voltmeter from the neutral point of the star connection at the far end of the line to earth. In order to determine in which wire the fault lies, the voltmeter must be connected successively between each wire and earth. In the discussion **Görges** pointed out that capacity currents are liable to be mistaken for leakage. In the Elektricitätswerk Wynan, Switzerland, the capacity current for 75 miles of overhead line at 9,000 volts amounted to half an ampere. With concentric cables in a three-phase system, the difference in capacity of the lines has a similar effect to leakage on the potential of the neutral point of the star connections. **Wilkens** pointed out that insulation tests made by connecting the circuit directly to the mains can be rendered perfectly safe, in case of a fault by putting a suitable known resistance in series. L. B.

174. *Measuring the Speed and Lag of Alternate-current Motors.* **R. Seemann.** (Elektrotechn. Ztschr. 20. pp. 764–766, November 2, 1899.)—This apparatus is constructed by Siemens and Halske, of Charlottenburg, and simultaneously determines the speeds of the motor and of the dynamo by means of two revolution-counters which can be thrown into and out of gear electrically. The difference between the two numbers of revolutions, reduced to equal numbers of poles, gives the lag. The two counters each comprise a worm spindle capable of being coupled to the respective shafts, and in connection with each worm, there is arranged a worm-wheel mounted on a spring-controlled lever which bears an armature arranged in conjunction with an electromagnet, so that when the electromagnets are connected up in the same circuit and energised, the two worm-wheels will be brought simultaneously into engagement with their worms. It is obvious that, by means of a chronograph and the above counters, the speeds of the dynamo and motor can be determined simultaneously, the percentage lag being obtained from the equation—

$$s = 100\left(\frac{u_1 - u_2}{u_1}\right) = 100\left(1 - \frac{u_2}{u_1}\right)$$

where s = the lag; u_1 the number of revolutions made by the dynamo, and u_2 the number of revolutions made by the motor in the same time. C. K. F.

175. *Platinum-clay Resistance Material.* **W. C. Heraeus.** (Zeitschr. Elektrochem. 6. pp. 43–46, July 13, 1899.)—The effect of alloying base metals such as iron or manganese with platinum is generally to produce a brittle compound; such alloys cannot very easily be used for resistance wire. As a substitute for metallic resistances, Küch mixes about 60 per cent. of platinum with 40 per cent. of clay. If rods of this mixture are heated to the melting-point in a reducing atmosphere, a stable compound results. With these precautions, the percentage of platinum may be diminished to 10 per cent. before conductivity is lost; percentages from 10 to 15 of platinum are best for most purposes. The degree of conductivity depends upon the formation of platinum-silicium, this occurs at temperatures over 1,200° C.; great care is therefore necessary in the heating process at about that temperature. Up to white heat, the resistance increases with temperature; there is then a reversal. Wires 0·5 mm. diameter can be made, having about 14 ohms resistance per 1 cm. R. A.

176. *New Measuring Instruments by Siemens and Halske.* **A. Raps.** (Elektrotechn. Ztschr. 20. pp. 665–670, September 14, 1899. Report read before the Elektrotechnischer Verein, February 28, 1899.)—The first instrument described in the paper is a wattmeter, whose design was originally suggested by a d'Arsonval galvanometer. In order to obtain a practically uniform radial field such as that which exists in this latter instrument, the series coil of the wattmeter is made up of a number of flat copper conductors of the shape shown in fig. 1. A coil, the upper and lower portions of whose turns consist of such circular conductors, produces a practically uniform radial field. In this is pivoted the fine-wire coil, which consists of 400 turns of wire 0·1 mm. in diameter,

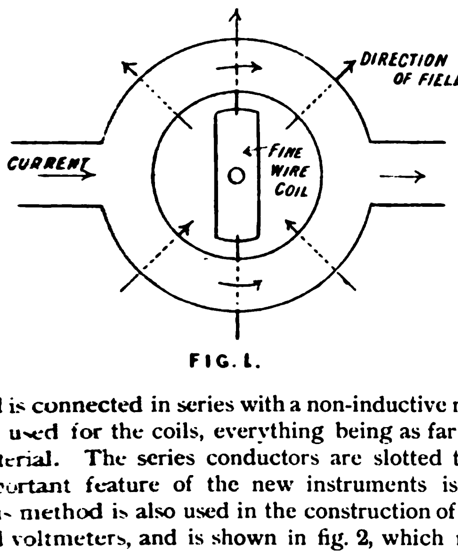


FIG. 1.

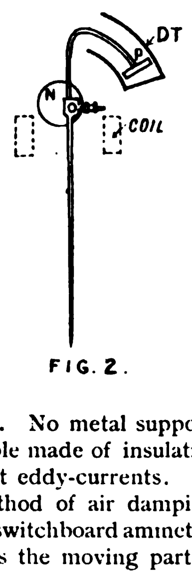


FIG. 2.

and is connected in series with a non-inductive resistance. No metal supports are used for the coils, everything being as far as possible made of insulating material. The series conductors are slotted to prevent eddy-currents. An important feature of the new instruments is the method of air damping. This method is also used in the construction of the new switchboard ammeters and voltmeters, and is shown in fig. 2, which represents the moving part of one of these instruments. The soft-iron needle N is of the shape shown, and is sucked into a coil placed immediately below it. The damping arrangement consists of a thin circular plate P provided with a rim and attached to the spindle by means of a very thin-walled tube of hard-drawn brass. The plate P moves with a very small clearance inside a damping tube DT. A. H.

177. *Thermophone.* **G. C. Whipple** and **H. E. Warren.** (Eng. News, 42. pp. 109–110, August 17, 1899.)—A modified Wheatstone bridge with galvanometer replaced by a telephone receiver in circuit with which is placed a vibrator resembling the vibrating armature and spring of an electric bell. Resistance coils, one at a known the other at an unknown temperature, affect the balance of the bridge by their relative variations in resistance under changes of temperature. When the balance is disturbed the instrument hums : but it can be silenced by adjusting the position of a pointer, whose movement alters the relation between two branches, and whose position enables the corresponding temperature of the distant resistance coil to be read off on a dial-scale. A. D.

178. *Instrument for Determining the E.M.F. of Accumulators.* (Zeitschr. Elektrotechn., Wien. 17. pp. 454–455, August 27, 1899.)—In this instrument, which is due to R. Hopfelt, of Berlin, the times at which the fall in the

electromotive force takes place at the end of the discharge, and at which it increases at the end of the charge, can be determined when currents are passing through the accumulator. The instrument consists of a kind of differential galvanometer, *e.g.*, a Weston voltmeter wound with two coils, one of which is connected through a suitable resistance directly to the terminals of the battery, whilst the other is connected in parallel with a resistance in the main circuit of the accumulator. The latter coil must be so connected to the series resistance that, when the accumulator is being discharged, the current will pass through it in such a direction that the effects of the two coils on the movable system of the instrument will be added. This is necessary, since the terminal potential difference is here smaller than the E.M.F. The theory of the instrument is based on the following assumptions, viz., that in a lead accumulator, so long as there is no considerable formation of gas-bubbles on the electrodes, the internal resistance changes very little, and moreover that the polarisation is very closely proportional to the current so long as the accumulator is not completely charged or discharged, *e.g.*, equal to c_p times the current. Towards the end of the discharge, the constant c_p however rapidly assumes a relatively high value ; likewise at the end of the charge, when gases are evolved, there is added to the ordinary polarisation, the gas polarisation, so that at this time the pointer begins to move rapidly in one direction or the other. A rise of E.M.F. is especially noticeable in charging, amounting to about 0·5 volt in a few minutes, so that the moment of complete charge can be very easily observed. Various other methods of using the instrument are described with reference to diagrams. C. K. F.

179. *Instruments for Three-Phase Circuits.* (Ind. Élect., 8. p. 486, October 10, 1899. Abstract of paper read by R. Arno, before the National Congress of Italian Electricians at Como.)—A paper dealing with the principles underlying the construction of certain forms of wattmeters and energy meters for use on three-phase networks. A. H.

180. *Measuring the Frequency of Alternate Currents.* **H. V. Carpenter.** (Elect. World and Engineer, 34. pp. 198–199, August 5, 1899.)—The method consists in turning a wire stretched between the poles of an electromagnet, and carrying the alternating current till its natural period is the same as that of the current, and calculating the periodic time from its length, weight, and the tension. The accuracy of the method is stated to be within one-fifth of 1 per cent. W. G. R.

181. *Measurement of Frequency.* **H. W. Smith.** (Elect. Engin. 24. pp 466–467, October 13, 1899 ; from the "Technology Quarterly.")—A weighted tuning fork, electrically driven, is provided with a sharp-pointed style attached to one of its prongs ; this style vibrates over a smooth surface formed by two blocks of ivory separated by a sheet of platinum about 0·02 inch in thickness This contact maker is connected in series with a telephone and attached to the source of alternate current. When the fork is set in vibration the style makes contact at the middle of each stroke of the prong, and if the frequency of the alternate current is the same as that of the fork the contacts will occur at the same point in each successive current wave ; there will then be a steady sound in the telephone or no sound, depending on the difference of phase between the fork and the current. If the frequency of the fork and the current differ there will be "beats" and the weights on the fork are shifted until there are no beats, and, as the fork has been previously rated, the frequency of th

current is determined. This paper then deals with a method of driving the fork electrically which is a modification of one given by W. G. Gregory in the Phil. Mag. (December, 1889, p. 400). E. C. R.

182. *Frequency Indicator.* **G. J. Yundt.** (Elect. World and Engineer, 34. p. 344. September 2, 1899.)—Suspended from a wooden stand is a vertical phosphor bronze wire (No. 26) which passes between the soft-iron pole-pieces of a permanent horseshoe magnet and conveys the current whose frequency is to be determined. The wire is stretched tight by a weight attached to its lower end, and immediately above the weight is a wedge of brass whose edge presses against the wire. A movable bridge, which is free to slide up and down a vertical scale, serves for adjusting the length of the vibrating wire, and so determining the corresponding frequency of the current. A. H.

183. *Phasemeter for Alternate Currents.* **R. Arnò.** (Écl. Électr. 21. pp. 225–226, November 11, 1899; also Elettricista, t. viii. p. 208, September 1, 1899.)—This instrument consists of a combination of an electro-dynamometer having its coils separate, and an instrument to produce a Ferraris field having two separate coils fixed at right angles with an extra closed-circuit movable coil placed inside them.

Let I_1 and I_2 be the two currents under test, α the deviation and ϕ the difference of phase, then we have in the dynamometer—

$$I_1 I_2 \cos\phi = \kappa' \alpha,$$

and in the Ferraris instrument—

$$I_1 I_2 \sin\phi = \kappa'' \beta,$$

whence—

$$\tan\phi = \kappa \frac{\beta}{\alpha}$$

Now to get a result by only one test the two instruments are connected together so that the two currents pass through their respective coils in both, which are separated by a copper plate to prevent mutual influence; the readings are taken on both instruments from which the tangent of the difference ϕ is deducted. E. C. R.

184. *Permeameter.* **C. P. Poole.** (Amer. Electn. 11. p. 429, September, 1899.)—This is a permeameter intended for workshop use. It is of the dynamo type, with massive pole-pieces and armature-core. The only point of novelty is that the speed is adjusted so that the permeameter is direct-reading. A voltmeter connected to the brushes indicates 1 volt for each 1,000 gausses in the specimen field-magnet core. For the theory of permeameters of this type see Abstract No. 618 (1899). R. A.

185. *Magnetic Intensity Variometers.* **M. Eschenhagen.** (Deutsch. Phys. Gesell., Verh. 1. pp. 147–152, 1899.)—The earth's magnetic force is usually balanced against the force of a permanent magnet or the directive force of a bifilar suspension. Both these forces are subject to changes with time and temperature. Quartz fibres are too weak for holding the usual magnetic systems, but the author has devised a light system which can be suspended by a single quartz fibre, and which offers great constancy and special facilities for photographic registration. E. E. F.

186. *Periodic Curve Tracers.* **R. Franke.** (Elektrotechn. Ztschr. 20. pp. 802–807, November 16, 1899. Read before the Seventh Session of the V

bandes Deutscher Elektrotechn. at Hanover, 1899.)—The author reviews the methods suggested by Frölich and by Joubert for tracing periodic curves. He also describes an improved form of apparatus patented by himself, for applying the Joubert method to practical measurements. It is taken for granted that the mechanism is to be used for tracing the current curves of alternators. Joubert took off the current at a given phase by means of a one-bar commutator; the current at successive phases could be determined similarly by twisting the commutator through successive angles, and by observing the corresponding steady deflections of a galvanometer. In the new apparatus the one-bar commutator is replaced by one with five sectors with narrow spaces between them. The fifth sector subtends twice the angle of either of the other four; and there are two brushes making peripheral contact at a distance apart equal to the width of the fifth sector. Such an arrangement makes contact momentarily once each revolution; the moment of contact can be readily adjusted, and the duration controlled. The five-bar commutator can be attached to the armature shaft, or it can be geared to it by means of a flexible drive. In the case of multi-polar machines change-wheels are provided, so that the commutator makes a complete turn for each period. The angular position of the contact can be adjusted by rotating a grooved wheel on the commutator. An endless cord, passing over the wheel, communicates similar angular displacements to a cylinder, around which the record paper is wrapped. The galvanometer "spot" is focussed upon the cylinder, and its position for each change in the commutation is marked by hand, with a pencil, on the record paper. Examples of curves traced by this apparatus are given, together with very clear illustrations of the mechanism. R. A.

187. *Determining the Wave Form of Polyphase Alternating Currents.* **H. J. Ryan.** (Amer. Instit. Elect. Engin., Trans. 16. pp. 865–877; Discussion, pp. 877–880, August and September, 1899.)—This method may be regarded as a development of that devised by Duncan (see Trans. Amer. Instit. Elect. Engin. 9. pp. 179 *et seq.*), wherein the current, whose wave form is to be determined, is passed through the fixed coil of a dynamometer, whilst the movable coil of the dynamometer is included in a circuit containing an accumulator and a contact-maker on the rotary shaft of the dynamo or motor. Instead of using the accumulator and contact-maker, the author employs an "impulse" transformer having a closed magnetic circuit of soft, pure iron, with the portion enveloped by the primary and secondary coils much restricted in area as compared with the remaining portion of the magnetic circuit, so that the flux through the core will cause saturation during 97 per cent. of the time the greater portion, therefore, of the secondary E.M.F. time-integral will occur during 1·5 per cent. of the time of one alternation and this E.M.F. will thus be delivered with great suddenness at the time when the exciting current passes through zero. In order to produce an impulsive current by this means at different parts of the cycle, so as to obtain different points on the curve the phase of the exciting current of the impulse transformer can be changed by phase-changing transformers or by an induction motor. In cases where the plus and minus alternations are different, one or more aluminium cells can be placed in series with the impulse secondary so as to cut off one or other side of the alternating impulse as desired. Full details of the connections and apparatus employed, including an auxiliary transformer for compensating for the residue of the secondary E.M.F., together with examples of curves compared with those obtained by the contact-maker method, are given in the original paper.

In the discussion which followed, **C. P. Steinmetz** and **C. A. Adams** described improved forms of contact-maker which have worked well in practice and **C. P. Mathews** described a method of obtaining wave forms in which a galvanometer of the oscillograph type and aluminium cells are employed.
C. K. F.

188. *Photographic Current Curves.* **J. Zenneck.** (Wied. Ann. 69. 4. pp. 838–853, December, 1899.)—Braun's kathode ray method may be modified so as to give current curves on to fluorescent screen itself, which may be exhibited in a lecture or photographed. To accomplish this the author imparts a lateral periodic motion to the vibrating spot of light on the screen by means of a second deflecting magnet excited by a synchronous current changing in a linear manner with the time. This current is taken off a wheel carrying a circular wire, and is inversely proportional to the length of wire in circuit at any instant.
E. E. F.

189. *Photographic Current Curves.* **A. Wehnelt** and **B. Donath.** (Wied. Ann. 69. 4. pp. 861–870, December, 1899.)—The Braun vacuum tube possesses several great advantages over other contrivances for demonstrating the variation of an electric current. Operating as it does with a kathode beam deflected by a magnet excited by the current under investigation, it offers a weightless lever whose displacement is practically perfectly proportional to the current strength. The authors have improved the arrangement and made it available for quantitative determinations. They dispensed with the revolving mirror, as the images obtained with it were too feeble. Instead, they photographed the spot of light on the fluorescent screen on a sliding plate, and photographed, side by side with it, the sinusoidal curve of a vibrating tuning-fork, obtained by attaching a pin-hole in aluminium foil to the prong in the path of a strong beam of light. The curves reproduced are very striking. Several of them show the course of the current from a Wehnelt interrupter under various conditions of capacity and inductance in the circuit. They all show the very rapid break, which practically obliterates that part of the curve altogether. One photograph shows the curves of current and E.M.F. and their relative displacement, obtained with two independent lenses and two luminescent screens at right angles to each other.
E. E. F.

190. *Doubling the Frequency of an Alternate Current.* **J. Zenneck.** (Wied. Ann. 69. 4. pp. 858–860, December, 1899.)—The author has devised an ingenious method of doubling the rate of alternation of an alternating current by means of a stationary transformer. He does it with the aid of two "aluminium valves," or carbon-potash-aluminium cells, which, as we know, only allow the current to pass from the aluminium to the carbon electrode. The alternating circuit is split into two branches, which are wound round the core of a transformer in opposite directions. Each of the branches contains an aluminium valve, but the valve is reversed in one branch with respect to the other. The effect of this is that one-half of the alternate current passes through one branch and the other through the other branch, but in an opposite direction, so that in reality two successive maximums act upon the transformer, instead of a maximum and a minimum. This of course amounts to a doubling of the original frequency, though the new current is no longer sinusoidal. Curves taken off the secondary coil of the transformer show such a doubling distinctly. The author has not obtained any very favourable curves that way,

where I, the impedance,

$$=\sqrt{R^2+\omega^2L^2+2\omega LR\sin\delta}$$

Also, if the angle AOD $=\phi$

$$e\sin\phi=\omega Lc\cos\delta$$
$$e\cos\phi=(R+\omega L\sin\delta)c$$
$$\therefore\quad \tan\phi=\frac{\omega L\cos\delta}{R+\omega L\sin\delta}$$

so that if the impressed E.M.F. $=e\cos\omega t$

then—
$$c=\frac{e}{I}\cos(\omega t-\phi)$$

Thus while hysteresis increases the impedance of the circuit it diminishes the lag of the current.

The power put into the circuit $=\frac{1}{2}ec\cos\phi$

$$=\frac{1}{2}\cdot\frac{OA.OG}{R}$$
$$=\frac{1}{2}\cdot\frac{OA^2}{R}+\frac{1}{2}\cdot\frac{OA.AG}{R}$$

of which $\frac{1}{2}\frac{OA^2}{R}$ or $\frac{1}{2}Rc^2$ is used in heating the circuit, and $\frac{1}{2}\frac{OA.AG}{R}$ or $\frac{1}{2}L\omega c^2\sin\delta$ is the power absorbed by hysteresis.

Now as $\omega=2\pi\times$ the frequency, the energy T absorbed per cycle by hysteresis is $\pi Lc^2\sin\delta$ or $\pi n^2\sigma c^2\sin\delta$, and as $\sigma=\frac{4\pi\mu a}{l}$ (where $l=$length, $a=$cross-section, and $\mu=$permeability of magnetic circuit) and the induction $b=\frac{4\pi nc}{l}$ we get—

$$T=\frac{b^2}{4\mu}\cdot v\sin\delta=\frac{bhv}{4}\sin\delta$$

where v is the volume of the iron and $h=\frac{b}{\mu}$.

Hence the energy T absorbed per cycle is—

$$T=\frac{vbh}{4}\sin\delta,$$

or per cubic centimeter per cycle—

$$T=\frac{bh}{4}\sin\delta.$$

W. G. R.

193. *Hysteresis of Cobalt.* **J. A. Fleming, A. W. Ashton,** and **H. J. Tomlinson.** (Phil. Mag. 48. pp. 271–279, September, 1899.)—The Cobalt ring used in the experiments described had the following composition :—

Cobalt	95·95 per cent.	Silicon	0·42 per cent.
Nickel	0·80 „ „	Carbon	1·36 „ „
Iron	0·91 „ „	Sulphur	trace.
Manganese	0·25 „ „	Phosphorus	trace

The test was performed ballistically, and the authors conclude that except at low inductions the hysteresis loss per cubic centimeter per cycle (W) can be expressed in either of the forms—

$$W=0{\cdot}01\,B^{1\cdot6}$$
$$\text{or } W=0{\cdot}527\,I^{1\cdot63}$$

where B is the maximum induction, and I is the maximum intensity c magnetisation.

W. G. F

194. *Alternating Current Theory.* **C. P. Steinmetz.** (Amer. Instit. Elect. Engin., Trans. 16. pp. 289–316; Discussion, pp. 317–324, 1899.)—In the first part of the paper, the author deals with the representation of the power in an inductive circuit by means of a vector graphically, or by means of a complex number analytically. The E.M.F. **E** and current **I** in a circuit may be represented by two vectors in an Argand diagram corresponding to the complex numbers $\mathbf{E}=e_x+ie_y$ and $\mathbf{I}=i_x+ii_y$ respectively (where $i^2=-1$). If we take the product **EI** of the two vectors, we find that this does not correspond to the power. The power vector is, in fact, a vector whose frequency is double that of **E** or **I**, and hence it cannot be represented in the same diagram with **E** and **I**. This leads us to consider the product **EI** when the phase angle is doubled. Forming this product, and remembering that now i^2 must be put $=+1$, since a rotation of π radians for **E** or **I** corresponds to a rotation of 2π for the product, we find $[\mathbf{EI}]=(e_xi_x+e_yi_y)+i(e_yi_x-e_xi_y)$, where the square brackets are used to indicate a doubling of the frequency. The real component of [**EI**] gives the true power in the circuit, and the imaginary component the wattless volt-amperes. By squaring and adding the two components, the square of the total volt-amperes or apparent watts in the circuit is obtained. The author points out that $[\mathbf{EI}]=-[\mathbf{IE}]$, so that the law of commutation ceases to hold in this case. The method of representing power just explained is applied by the author to the problem of two polyphase induction motors coupled mechanically and electrically, the 2ary of the 1st motor being closed by the 1ary of the 2nd motor. In the 2nd part of the paper, the author considers the symbolic representation of E.M.F. and current waves of irregular shape. In many cases, instead of considering such waves, we may use equivalent sine waves. In other cases, however, especially in circuits containing capacity or periodically varying resistance or reactance (*e.g.*, alternating arcs, synchronous induction motors, over saturated magnetic circuits, &c.), the use of an equivalent sine wave is not permissible. The author proposes to use the following symbolism in such cases. The general alternating wave of E.M.F., viz., $E=E_1\sin(pt-a_1)+E_3\sin(3pt-a_3)+\ldots$ may be written in the form $\mathbf{E}=\sum_{n=1}^{n=\infty} 2n-1(e_n+i_ne'_n)$, where $i_n^2=-$ the suffix n merely denoting that the components of the various terms represent different frequencies, and thus cannot be combined. If now the impedance of the fundamental harmonic be represented by $z_1=r+i(x_m+x_o+x_c)$, where x_m stands for that part of the reactance which is proportional to the frequency (inductance, &c.); x_o for the part independent of the frequency (mutual induction, synchronous motion, &c.); and x_c for the part which varies inversely as the frequency (capacity, &c.), then the impedance for the n harmonic is $z_n=r+i_n(nx_m+x_o+x_c/n)$, and the current may be represented

$$\sum_{n=1}^{n=\infty} 2n-1\ \frac{e_n+i_ne'_n}{r+i_n(nx_m+x_o+x_c/n)}.$$

The use of this symbolism is illustrated numerical examples.

In the discussion, **L. Bell** called attention to the imperfection of ordinary sine wave calculations when applied to long lines having combined inductance and capacity. **D. C. Jackson** contributed the following note a method of treating the power vector, which he considers simpler than Steinmetz's method. Let $\text{cis}\,\theta=\cos\theta+i\sin\theta$, so that $\text{cis}\,\theta$ represents operation of turning a vector through an angle θ. Writing $\mathbf{E}=E\,\text{cis}\,\theta$, $\mathbf{I}=I\,\text{cis}(\theta-\phi)$, and denoting the power vector by **P**, we have $\mathbf{P}=\mathbf{EI}=\text{cis}(2\theta-\phi)=(EI\cos\phi-iEI\sin\phi)\,\text{cis}\,2\theta$, and it is clearly seen that **P** has tw

the frequency of I and E. Moreover, the ordinary commutative law is valid in this case.

A. H.

195. *Phase-Angle Measurements.* **E. Place.** (Elect. World and Engineer, 33. pp. 614–616, 1899.)—The author describes the actual performances of a phase-angle instrument based upon Rayleigh's soft-iron needle device. They were interesting, though not quite satisfactory, mainly owing to a difficulty in defining the phase angle when current and voltage do not follow the sine law.

E. E. F.

196. *Large Phase Displacements.* **J. Görner.** (Elektrotechn. Ztschr. 20, pp. 750–751, October 26, 1899.)—In alternate-current work, phase displacements of ninety or more degrees cannot be obtained by the use of inductances

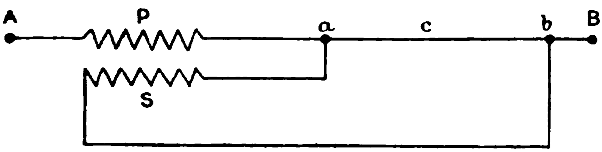


FIG I

or condensers. The author describes several systems of connection which gives the required high phase-difference. In fig. 1, A and B are the alternate current terminals, P and S are the primary and secondary coils of a transformer respectively. The displaced current traverses the portion *a c b*. A

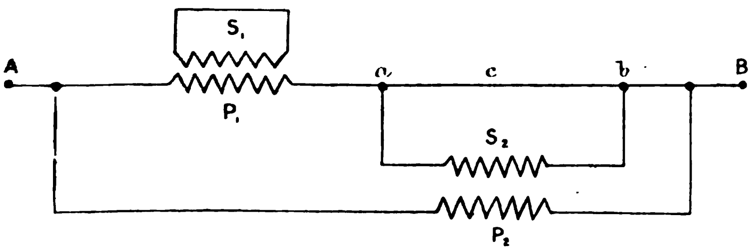


FIG 2.

practically perfect independence of the voltage may be attained by using two transformers, as in fig. 2, and suitably adjusting the work in the two secondary coils. This type is used by Hartmann and Braun for their direct-reading phase-meter.

E. E. F.

197. *Magnetism and Thermoelectric Properties of Bismuth and its Alloys.* **G. Spadavecchia.** (N. Cimento, 10. pp. 161–168, September, 1899.)—The variations of thermoelectric electromotive force in alloys of bismuth and lead under the influence of magnetism increase with the variation of the magnetic field. In some alloys the changes in the thermoelectric power have different values according to the direction of the magnetisation. Under a given magnetic field the variations in the thermoelectric power progressively increase from pure bismuth up to a percentage of 0·094 of lead, and change sign between

0·094 and 0·15 per cent. Then the variations progressively increase up to a second change of sign at an alloy containing a little over 14 per cent of lead. Finally they change sign again at about 50 per cent., and diminish all the way down to pure lead. (See also 1899, Abstract No. 1931.) A. D.

198. *Molecular Susceptibilities of Paramagnetic Salts.* **A. P. Wills** and **O. Liebknecht.** (Deutsch. Phys. Gesell., Verh. 1. pp. 170–178, 1899.)—The authors determined the magnetic susceptibilities of the fluorides, chlorides, bromides, iodides, sulphates, and nitrates of chromium, manganese, iron, nickel, cobalt, copper, snd some rare metals by du Bois's method of non-magnetic solutions. E. E. F.

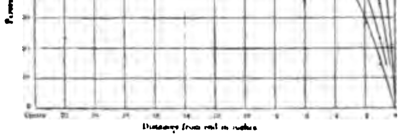
199. *Magnetism.* **J. A. Ewing.** (Instit. Civ. Engin., Proc. 138. pp. 289 - 311, October, 1899.)—This is the "James Forrest" Lecture which the author delivered before the Institution of Civil Engineers. It contains a general review of the progress in magnetism and of the various commercial uses made of magnetic metals. W. G. R

200. *Magnetic Properties of Iron at Low Temperatures.* **G. Claude** (Comptes Rendus, 129. pp. 409–412, August 21, 1899.)—At a temperature o —185°, and at high induction densities the permeability and hysteresis los of iron is sensibly constant, for varying magnetising forces, save for a sligh tendency towards diminution.

For low induction densities the permeability and hysteresis loss diminis with the temperature in a very pronounced manner. W. G. I

201. *Magnetic Induction in a Long Iron Bar.* **C. G. Lamb.** (Phil. Ma 48. pp. 262–271, September, 1899.)—In order to get a sufficiently clear notic of the induction distribution in a long iron bar, and how it is produced, it desirable to determine the following data :—

(P) A curve of magnetisation of the bar as determined by means of search coil at its centre.



(Q) A series of curves for various fixed magnetising forces showing distribution of induction in each case.

(R) A magnetisation curve of the bar when made into a ring, so that induction is the same at every cross-section.

The bar used was a circular bar of Low Moor iron ; it was 0·485 cr mean diameter and 123·4 cm. long.

The test was made ballistically, and the accompanying curves obtaine *which the letters P, Q,* R refer respectively to the three data given al

W (

202. *Magnetism and Elasticity of Rods.* **J. S. Stevens** and **H. G. Dorsey.** (Phys. Rev. 9. pp. 116–120, August, 1899.)—The authors support the rods, whose length is about 66 cms., on knife edges near the ends: in the centre of the rod, suspended from a hook, is the load causing the deflection, and in the upper surface one of the mirrors of an interferometer. Surrounding the rod is first an air space, then a chamber for the passage of a stream of water, and on the outside two series of coils for the magnetising current. The rods were of steel and also of wrought iron. The results obtained were that the modulus of elasticity of wrought iron and steel increased with magnetisation; in the case of steel little difference was observed for loads of 1 kilogramme and ½ a kilogramme, but in wrought iron the smaller load gave the greater displacement when equal magnetising forces were used. E. C. R.

203. *Distribution of Magnetic Flux.* **P. Gasnier.** (Ind. Élect. 8. pp. 414–416, September 25, 1899.)—Experiments are described for determining the distribution of flux in permanent magnets, and to ascertain whether the total flux in the case of a horseshoe magnet is modified in value by the presence or absence of the armature. A quotation is cited from a translation of S. P. Thompson's book on the electromagnet, to the effect that with a horseshoe magnet of iron or steel magnetised "*une fois pour toutes*" the flux at the bend of the shoe is a fixed quantity, unaffected by alterations of the reluctance in the rest of the magnetic circuit. The results of the present experiments are shown as curves expressing the flux in webers at different points along a horseshoe magnet, (1) with an armature; (2) without an armature. The two curves, corresponding to (1) and (2) respectively, never coincide: it is therefore concluded that the flux is different in the two cases. It appears, however, from the curves, that the flux at the middle point of the bend approaches a constant value, especially for large magnets. From this middle point the divergence between the two curves increases somewhat slowly until about one-fourth of the straight portion has been traversed from the bend. R. A.

204. *Hysteresis Loss in Transformers.* **W. Peukert.** (Elektrotechn. Ztschr. 20. pp. 674–677, September 21, 1899.)—An inquiry into the limitations of the Steinmetz formula for arriving at the hysteresis loss of all alternate current transformers, in which—

$$W = n \,.\, B_{max}^{1\cdot6}\, p \,.\, V \,.\, 10^{-7},$$

W representing the watts lost,
n a constant depending on the quality of iron,
B the magnetic lines per sq. cm.,
p the periodicity per second,
V the total volume of the iron in cub. cm.

A table is given showing that whilst the constant n might be 0·002 for a given sample of iron at the values for B usually employed in transformers' work, the constant may increase as much as 70 or 80 per cent. when carried to higher values thus:—

$B_{max.}$	n	$B_{max.}$	n
2660	0·00222	12250	0·00256
4698	0·00221	14124	0·00301
6756	0·00224	15838	0·00372
10197	0·00246	17243	0·00393

The results of a series of tests on a transformer are tabulated for the various periodicities, viz., 24, 30, 33·3, 37·3, 41·3, 46·67, 50·67, 54·67, and the following maximum values of B, viz., 2,187, 3,522, 4,173, 5,192, 5,848, and 6,260. The author gives the following formula for arriving at a suitable B for different periodicities, &c.

$$B_{max} = \frac{0{\cdot}9E \,.\, 10^8}{4 \,.\, p \,.\, m \,.\, q}$$

Where E is the voltage,
p the periodicity,
m the number of turns of coil,
and q the cross-section of the iron in sq. cms. E. K. S.

205. *Magnetoelectric Rotations.* **W. de Nikolaiève.** (Comptes Rendus, 129. pp. 475–477, September 18, 1899.)—A brass rod is suspended inside a hollow cylinder so that the two can rotate independently, a current being sent through them in series by mercury contacts. The system is placed in a strong magnetic field. The cylinder and the rod then rotate in opposite directions, being acted upon independently by the magnet. When they are rigidly connected the system stops, or nearly stops, any residual rotation being due to want of symmetry in the distribution of the currents. E. E. F.

206. *Magnetism and Molecular Rotation.* **G. F. Fitzgerald.** (Electrician, 43. pp. 582–583, August 4, 1899.)—Although Lord Kelvin has discarded the gyrostatic hypothesis of matter as unable to account for the Zeeman effect, the author points out "a modification of Lord Kelvin's molecule by which the difficulty of producing thin lines is surmounted, while rotation of the plane of polarisation is produced by the rotation of part of the molecule. Imagine one of Lord Kelvin's spherical atoms immersed in a soft jelly. It consists of a thin spherical shell attached to the jelly. Inside this place a concentric spherical shell, separated from the first by a symmetrical system of perfectly smooth, non-conducting springs, so that the inside sphere may be able to turn round freely in any direction inside the outer one. Inside the inner sphere is suspended centrally, by a symmetrical system of springs, a heavy particle. This system can, by the oscillation of the inside heavy particle, emit a vibration of a definite frequency, *i.e.*, a thin line to the spectrum. Now, if the outer sphere be positively and the inner one negatively electrified, and the whole be subject to a growing magnetic induction, the outer sphere will be given a twist in one direction and the inner in the opposite direction. The attachment of the outer sphere to the jelly will prevent it from taking up continuous rotation, but the inner sphere will rotate round the diameter parallel to the magnetic induction, and, being supported by perfectly smooth springs, will continue rotating as long as the magnetic induction lasts. When the magnetic induction ceases this will produce a twist on the rotating electrified sphere which will stop its rotation. During its rotation the sphere will carry round with it the central heavy particle. If this latter be vibrating its vibrations will be affected by the rotation, and if it be kept in vibration by a plane polarised wave motion, traversing the jelly in the direction of the axis of rotation, this rotating molecule will react upon the jelly in such a way as to produce a rotation of the plane of polarisation such as is required to illustrate the Faraday rotation." E. E.

207. *Magnetic Shielding.* **A. P. Wills.** (Phys. Rev. 9. pp. 193–21[illegible] October, 1899.)—A theoretical discussion of the shielding effects produced

triple concentric spherical and triple coaxial cylindrical shells. The author refers to the work of du Bois (see 1898, Abstract No. 954) on this subject, and deduces expressions for the shielding effect due to triple shells in terms of the geometrical data of the shells and the (constant) permeability of the material. The paper contains three sets of diagrams referring to uni-, bi-, and tri-lamellar shields respectively, and showing the variation of the shielding effect with thickness of shell. A. H.

208. *Electric Railways and Magnetic Observatories.* **J. Edler.** (Deutsch. Phys. Gesell., Verh. 1. pp. 174–180, 1899.)—Measurements with an intensity variometer, carried out in Berlin and Spandau, show that in the case of an electric railway with a return along the rails the distance between the railway and a magnetic observatory should not be less than 8 km. For the most delicate measurements a distance of 15 km. does not guarantee absolute safety, but special tests must be made for each individual case. E. E. F.

209. *Magnetic Elements in Italy.* **L. Palazzo.** (Accad. Lincei Atti, 8. pp. 22–28, July 2, 1899.)—The author gives the values of the magnetic elements at twenty-three stations observed in 1891–2. The stations were chosen so as to investigate the disturbances due to volcanic rocks. (See also 1898, Abstract No. 270.) W. W.

REFERENCES.

210. *Electrolytic Interrupter.* **W. Ziegler.** (Wied. Ann. 69. 3. pp. 718–719. November, 1899.)—A claim of priority by the author for himself and F. Richarz. Refers to paper by H. T. Simon (see 1899, Abstract No. 1919). E. E. F.

211. *Wehnelt and Caldwell Interrupters.* **M. Lamotte.** (Écl. Électr. 21 pp. 41–46, October 14th; pp. 127–137, October 28, 1899.)—On the form of current produced in, the difference of potential between the terminals of, and the energy dissipated in, liquid interrupters.—(Pp. 180–184, November 4th) Illustrating modifications of Wehnelt and of Simon and Caldwell interrupters.—(Pp. 250–256, November 18th) Explanation and application of Wehnelt interrupter and work of E. Lecher.

212. *Animal Electricity.* **W. S. Hedley.** (Elect. Rev. 45. pp. 468–469, September 22, 1899.)—Abstract of Burdon-Sanderson's Croonian Lecture. H. B.

213. *Electricity before Volta.* **E. de Fodor.** (Zeitschr. Elektrotechn., Wien. 17. pp. 563–569, November 5, 1899.)

214. *Electric Progress.* **E. J. Houston.** (Cassier, 17. pp. 145–153, December, 1899.)—Historical data, both purely scientific and technical.

215. *Sounds emitted by the Electric Arc.* **F. J. Jervis-Smith.** (Electrician, 44. p. 16, October 27, 1899.)—Note on the sound emitted by an arc on making the circuit of an electrolytic interrupter.

216. *Alternating Currents of very High Frequency.* **W. G. Royal-Dawson.** (Instit. Elect. Engin., Journ. 28. pp. 655–658, August, 1899.—Abstract of paper read before Students' Section.)

217. *Volta and the Voltaic Cell.* **A. Righi.** (Elect. Rev. 45. pp. 694–696, October 27, 1899.)—*A lecture delivered in Como, September 18, 1899.*

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

218. *Place of the New Constituents of the Atmosphere in the Periodic System.* **J. L. Howe.** (Chem. News, 80. pp. 74–76, August 18, 1899.)—The author adopts, with slight modifications, Venable's form of Mendeléef's periodic table, and considers helium, neon, and argon to be the first three members of the eighth group. These three elements form a transition between the strongly electronegative halogens and the electropositive alkali metals. Neon is placed in the same horizontal line with fluorine and is the transitional element between that halogen and sodium, whilst argon lies between chlorine and potassium. Helium is placed in the same line with hydrogen and therefore precedes lithium; the corresponding halogen is, however, unknown. Too little is yet known of krypton, metargon, and xenon to allow the position of these elements to be settled; they will probably find a place in the eighth group. N. L.

219. *Relations between Properties of the Elements and their Atomic Weights.* **W. Sander.** (Elektrochem. Ztschr. 6. pp. 133–137, October, 1899.)—Remarks on the periodic nature of the properties of the elements. The author gives curves to exhibit this periodicity in the case of (*a*) linear coefficient of thermal expansion, (*b*) migration-velocity in normal solutions, (*c*) metallic conductivity, (*d*) potential-difference between a metal and a normal solution of one of its salts. In the last case the periodic curve drawn by the author does not suffer from want of novelty, as it contains no less than five double-points. F. G. D.

220. *Absorption of Water in Hot Glass.* **C. Barus.** (Phil. Mag. 47. pp. 461–479, 1899.)—Continuation of the author's work (see 1899, Abstract No. 1045) on the solution of glass in water at high temperatures (210° C.) and pressures. The apparatus used was the same as that described in previous papers. The first result of the reaction is an opaque layer, after which the aqueous silicate appears as a clear transparent viscous thread inside the glass capillary. The compressibility rises at first rapidly, attains a maximum, and then falls off to the probable value for pure water at 200° C. The action shows a definite limit when the solution has reached a certain concentration, which would appear to be in favour of the view that one is dealing with ordinary solution or with the formation of a definite compound. The author, however, adduces reasons for viewing the solution as *colloidal*. He regards the first or opaque stage as the swelling of a coagulated colloid in contact with its solvent. The subsequent clear stage is regarded as due to the fusion of this *saturated* and coagulated colloid. According to the author the reaction considered as a thermodynamic process is a march through the *critical region* of certain phases of the water-glass in question. F. G. D.

221. *Function of the Medium in the Process of Solution.* **J. W. Brühl.** (Zeitschr. Phys. Chem. 30. pp. 1–63, October 13, 1899.)—The phenomena of tautomerism or isodynamic change are eminently adapted to the investigation of processes of solution, and for this purpose the behaviour of methylic and ethylic mesityloxidoxalate in various media was studied, the conversion of the [illegible] into the ketonic form of these substances being readily determined [illegible]ometrically, since the refractive and dispersive powers of the two

isomerides are widely different. The experiments were carried out at the ordinary temperature, and the effect of the process of dissolution itself, of dilution, and of the continued action of the solvent was examined. Neither mere solution of the substance nor dilution produces isomeric change, these processes being, in the main, analogous to vaporisation; whilst the specific, chemical action of the solvent, as manifested by the passage of the enolic to the ketonic form, is only exerted under the influence of time. In this respect the effect of chloroform is extraordinarily small; benzene, carbon bisulphide, and α-bromonaphthalene are considerably more active; and in methyl or ethyl alcohol the isomeric change takes place comparatively quickly. In all cases the reaction tends towards the complete conversion of the one form into the other, and not towards a state of equilibrium. The formation of the ketonic form is considered to be preceded by the ionisation of the dissolved enolic isomeride, and in this latter process the physical properties of the medium may be expected to have an important influence. Thus it is observed that isomeric change occurs most readily in those media which possess a high dielectric and dissociating power; with these properties are usually associated a high specific heat and high heats of fusion and vaporisation. N. L

222. *Reciprocal Solubility of Liquids.* **G. Bruni.** (Accad. Lincei Atti, 8. pp. 141–149, September 3, 1899.)—The author studies the equilibrium of mixtures of water and methylethylketone in which ethyl alcohol is always present in the proportion of 1·5 per cent. of the total quantity of the mixture. Taking concentrations as abscissæ and temperatures as ordinates, he obtains a *closed* oval curve. The curve conforms to the law of the straight diameter, i.e. the locus of the middle of chords parallel to the axis of the abscissæ is approximately a straight line. He also experiments on the temperature of solidification of the mixtures. A. G.

223. *Solubility-coefficients of Liquids.* **A. Aignan** and **E. Dugas.** (Comptes Rendus, 129. pp. 643–645, October 23, 1899.)—The authors determine the coefficients of mutual solubility of two liquids by a method which does not appear to differ in principle from that used by Nernst. The two liquids are shaken in a graduated tube and the changes of volume read off. Two observations with different initial volumes give the two coefficients required. Three cases are distinguished.

1. The two liquids do not react with each other. The authors assume there will be no contraction or expansion of total volume.

2. The liquids combine. The authors assume there will be contraction of mixture.

3. Cases where there are in reality *more* than two components, although only two are supposed to be present.

From their experiments the authors conclude that aniline and water do not react, but that amyl alcohol and water do. They further conclude that the pure amyl alcohol of fermentation is a mixture. F. G. D.

224. *Hydrates in Solution.* **W. D. Bancroft.** (Journ. Phys. Chem. 3. pp. 551–554, November, 1899.)—The author makes some deductions from the mass-law concerning hydrates in solution. *His conclusions are*:—

1. Hydrated electrolytes *are decomposed by dilution.*

2. The *presence in solution of a hydrated electrolyte* will not account for

variations from Ostwald's dilution law, except in so far as it is not permissible to treat the concentration of the water as constant.

8. Treating the concentration of the water as constant, the ratio of the concentrations of a hydrated and a dehydrated ion will remain the same, provided there is no secondary electrolytic dissociation. F. G. D.

225. *Origin of Symmetry in Crystals. Polymorphism.* **F. Wallerant.** (Comptes Rendus, 129. pp. 775–778, November 13, 1899.)—The symmetry of crystals is considered as the result of the progressive transformation of limited into real elements of symmetry; the chemical molecules, exercising on exterior points actions which distribute themselves nearly symmetrically with regard to certain elements, group themselves into fundamental particles having geometrically limited elements, and these, in their turn, form complex particles, having a real symmetry. The limited elements of the complex particles finally become the elements of the crystal groupings. Should the angles between the limited elements of the fundamental particle differ from those between the angles of a polyhedron, the symmetry of the comple particle, though containing the same number of fundamental particles, ma vary. The networks will be identical, or only slightly different, but the re elements of one form which are wanting in another become the real elemen of the crystal groupings in the latter. If the external conditions vary, tl fundamental particles may themselves undergo modification, and tl symmetry of the complex particle may vary by the transformation of limit into real elements, and inversely. N.

226. *Formation of Glauberite.* **J. H. van't Hoff** and **D. Chiaravigl** (Preuss. Akad. Wiss. Berlin, S.ber. 42. pp. 810–818, November 2, 1899. This investigation forms another of the series of researches undertaken w the view of explaining the Stassfurt salt deposits. The previous investigati (see 1899, Abstract No. 1939) have dealt with the more soluble chlorides : sulphates of potassium, sodium, and magnesium. The present one deals v the less soluble sulphates of calcium and the double sulphates of calcium magnesium, and calcium and sodium. J. B

227. *Transformation of Styrolene by Light.* **G. Lemoine.** (Com Rendus, 129. pp. 719–722, November 6, 1899.)—Styrolene or cinnamene, C changes by heat in darkness into a polymer, metastyrolene. This same merisation is produced at ordinary temperatures by sunlight, but slowl one hour from 1 to 3 per cent.); the mixture remains homogeneous, fo metastyrolene dissolves in styrolene in excess. The blue and ultra- radiations are especially active in producing the change. The prin action of the light is to *accelerate* an exothermic transformation, which v be produced in darkness at the same temperature, but much more slowl J

228. *Guttapercha.* **Spranger.** (Archiv. Post. Tele. 23. pp. 93 December, 1899.)—This paper is an account of the distribution and pro of the gutta plant, statistical figures as to import, mode of purificatio the physical and chemical characteristics of the purified material chiefl from E. Obach's paper (see 1898, Abstracts Nos. 537 and 831), and als *Gummi, Guttapercha and Balata*, by Franz Clouth, Leipzig, 1899. (

229. *Solidification of Hydrogen.* **J. Dewar.** (Comptes Rendus, 1 451–454, September 4, 1899. Also Nature, 60. p. 514, September 21

paper read before the British Association.)—In order to obtain solid hydrogen, a small double-walled test tube was filled with the liquid and suspended in a bath of liquid hydrogen contained in a larger double-walled tube. The pressure was then diminished to 10 mm., but no solidification occurred. It is subsequently shown that this is due to superfusion. In the course of measurements of the boiling-point of liquid hydrogen under diminished pressure, made by means of electrical resistance thermometers, a small quantity of air leaked into the apparatus and solidified; under these circumstances the hydrogen solidifies to a kind of solid foam when the pressure is reduced below 60 mm. To decide whether this foam is really solid hydrogen, a flask of 1 litre capacity, to which a long glass tube and a small manometer were sealed, was filled with hydrogen and closed. The glass tube was immersed in liquid hydrogen boiling under reduced pressure. At 30–40 mm. the latter solidified to a mass of foam, and it was found that the narrow tube was full of a transparent solid, which, however, enclosed some gas bubbles near its surface. The maximum density of the liquid was 0·086. Solid hydrogen melts when its vapour pressure reaches 55 mm. The melting-point was determined by two hydrogen thermometers; resistance thermometers are unreliable at these low temperatures. The temperature of the solid hydrogen was 16° absolute at 35 mm. At 760 mm. liquid hydrogen boils at 21°, the vapour pressure of liquid hydrogen (in mm.) is therefore approximately represented by $\log p = 6{\cdot}7341 - 83{\cdot}28/T$, from which the freezing-point (at 55 mm.) is calculated to be 16·7° absolute. The freezing-point on the absolute scale is therefore almost half the critical temperature (30° to 32°).

T. E.

230. *Heat of Oxidation of Tungsten.* **Delépine** and **Hallopeau.** (Comptes Rendus, 129. pp. 600–603, October 16, 1899.)—The authors have determined the heats of oxidation of W and WO_2 with the following results:—

$$W + 3O = WO_3 + 196{\cdot}3 \text{ cal. (const. press.)}$$
$$WO_2 + O = WO_3 + 64{\cdot}9 \text{ cal.} \quad ,, \quad ,,$$
whence—
$$W + O_2 = WO_2 + 2 \times 65{\cdot}7 \text{ cal.} \quad ,, \quad ,,$$

They employed the calorimetric bomb, using oxygen at 25 atmospheres for W, and at 15 atmospheres for WO_2, and avoided the use of iron wire, substituting for it 0·01–0·03 gr. camphor, which was ignited by 0·01 grm. guncotton. Comparisons are made with other heats of oxidation, and deductions made therefrom by means of Berthelot's principle of maximum work. Tungsten does not reduce silica, alumina, magnesia, nor oxide of zinc. On the other hand, it easily reduces the oxides of antimony, lead, and copper at the temperature of an ordinary Bunsen flame. F. G. D.

231. *Direct Determination of Heat of Formation of Aluminium Bromide.* **N. Beketoff.** (Acad. Sci. St.-Pétersbourg, Bull. 10. pp. 79–81, 1899.)—The heats of formation of most chemical compounds are determined by indirect methods. Since the indirect method involves the determination of the heats of a number of reactions, the final result will involve all the errors made in these determinations. The author has determined by a *direct* method the heat of formation of Al_2Br_6, and finds it to be 41,000 calories—a value which is intermediate between that given by Thomsen (40,000) and that determined by Berthelot (42,000). The method of *experimenting* consisted in introducing accurately weighed *quantities of bromine into an* aluminium vessel. The

bromine was sealed up in small glass spheres, which were wrapped up in aluminium foil, aluminium filings being packed on the top of the spheres. Since bromine readily attacks aluminium at ordinary temperatures, the reaction commenced as soon as the glass spheres were broken. The aluminium vessel into which the spheres were dropped could be lowered into a water calorimeter, the thermal capacity of which was such that a temperature rise of not less than 2 and not more than 3 degrees was produced, so that the loss of heat by radiation during the experiment was very small. A. H.

232. *Velocity of Detonation of Acetylene.* **Berthelot** and **Le Chatelier.** (Comptes Rendus, 129. pp. 427–434, August 28, 1899.)—The acetylene was exploded in horizontal glass tubes about 1 m. long and of 2 mm. to 6 mm. in diameter, and was operated with at various pressures between 5 and 30 kg. per sq. cm. The velocity was registered by a falling photographic apparatus, released at the moment of detonation. The image of the horizontally moving flame in the tube, combined with this vertical movement, gave a curve on the photograph, from which at any point the velocity could be found. In some cases the trace was almost a straight line, but in others it showed a velocity increasing to a maximum. The results indicate that the velocity depends upon the initial pressure of the gas, from about 1,000 m. per sec. at 5 kg. per sq. cm. to 1,600 at 30.

The differences in character between the case of acetylene and the explosion of, say, oxygen and hydrogen, is pointed out. In their case bodies are formed which dissociate at temperatures reached in the explosion, so that the action is not so uncontrolled as when the products are those of decomposition only. F. T. T.

233. *Gas Reactions in Chemical Kinetics.* **M. Bodenstein.** (Zeitschr. Phys. Chem. 29. (I.) pp. 147–158, (II.) 295–314, (III.) 315–350, (IV.) 429–448, (V.) 665–699, and (VI. and VII.) 30. pp. 113–139, May–October, 1899.)

I. Gas reactions have the advantage over those in the liquid state that they can be extended over wide temperature intervals (200°–300°). The approximate uniformity of the temperature coefficient of the latter arises from the fact that all have been investigated within about the same range of temperature: by theory a falling off at high temperatures of the rate of increase of reaction velocity is to be expected, as is in fact found in the case of the following gases. "Pseudo-equilibrium" has been put forward experimentally by Pélabon and Hélier, and theoretically by Duhem, and is now investigated by the author.

II. The theory is tested with HI between 283° and 508°. The heat-production (Wärme-tönung) q, calculated from the coefficients of equilibrium, is found to vary considerably with the temperature, and is of the form $A+BT+CT^2$, and therefore K, k_1 and k_2, each of the form—

$$\log K = -\frac{A}{RT} + \frac{B}{R} ln T + \frac{C}{R} T + \text{const.}$$

The relation $K=k_1/k_2$ is found to hold between 356° and 508° within th somewhat wide limits of experimental error; the differences below 356° (u to 35 per cent.) may be due to the failure of iodine vapour to obey the laws (an ideal gas. The value of q extrapolated to 20° agrees but poorly with th observed in the calorimeter. The increase of velocity of decomposition f(10° rise of temperature between 300° and 500° is somewhat less (1·9 to 1 times) than that observed for liquid reactions at ordinary temperatures.

III. The combination of hydrogen and sulphur is found to be practical

complete at 300°–500°, and the inverse reaction only reached a few tenths per cent. after long heating; Pélabon's "pseudo-equilibria" are therefore only erroneous observations due to shortness of time. The velocity of combination is determined at 356° for varying H_2 concentration with constant vapour pressure of sulphur, and also for varying concentrations of sulphur, and found to be proportional to the former and nearly to the square root of the latter, the formula, $dx/dt=k(a-x)(b-x)^{\frac{1}{2}}$, where a and b are the original concentrations of hydrogen and sulphur, agreeing best with the results. This the author explains by supposing that the reaction takes place in three stages—

$$S_8=4S_2$$
$$S_2=2S$$
$$H_2+S=H_2S,$$

of which the first is negligeably slow, the second (almost) negligeably fast, and the third is that of which the velocity is measured. The concentration of S must then be proportional to the square root of that of S_2, and the latter will be practically proportional to that of S_8. The increase of velocity for every 10° rise of temperature is comparable (1·4 to 1·8) with that observed in liquid reactions.

IV. Hydrogen selenide decomposes, and likewise is formed much faster, when the walls of the containing vessel are coated with selenium, and the proportionality between the velocity and the quotient, surface/volume, indicates that the reaction takes place entirely on the surface. The equilibrium attained is the same for both formation and decomposition when sufficient time is allowed, thus disproving Pélabon's "pseudo-equilibria." Other criticisms of Pélabon's paper are also given.

V. The combination of H_2 and O_2 between 482° and 689° is studied by passing the gases, mixed in different proportions, through clean porcelain tubes, and measuring the diminution in volume. The time spent by each portion in the heated tube is calculated and the velocity of combination determined. The reaction is found to take place exclusively on the walls of the tube, and is shown by the satisfactory constancy of the calculated coefficient to be *trimolecular*, in accordance with the equation—

$$2H_2+O_2=2H_2O.$$

The velocity varies with the tube used, and its temperature coefficient is somewhat uncertain. The formula—

$$\log k=-\frac{16298}{T}-48{\cdot}455\log T+163$$

is given. At the highest temperatures the transition to an explosive reaction was clearly shown, in accordance with van't Hoff's explanation, the velocity rising, owing to evolution of heat, more rapidly than the walls of the tube could equalise. Hélier's "pseudo-equilibrium" was not observed.

VI. Various forms of baths and thermostats for constant high temperatures are described, applicable from 100° to 700°.

VII. Summary of results. B. B. T.

234. *Pseudo-Equilibria.* **P. Duhem.** (Zeitschr. Phys. Chem. 29. pp. 711–714, September 15, 1899.)—A reply to the criticisms of Bodenstein on Pélabon's work. The author points out that Bodenstein may have erred in overlooking the solvent action of melted sulphur *on the sulphuretted* hydrogen produced in the reaction between *hydrogen and melted sulphur.* If enough sulphur

were present this might make the reaction appear unlimited, in accordance with Bodenstein's results. As Pélabon has found that a very considerable absorption of sulphuretted hydrogen by sulphur does occur, and as Bodenstein does not appear to have allowed for this, the author challenges the accuracy of Bodenstein's results. F. G. D.

235. *Chemical Equilibrium in Systems of Two and Three Bodies.* **V. Kouriloff.** (Acad. Sci. St.-Pétersbourg, Mem. 8. 4. pp. 1–93, 1899.)—An elaborate treatise on the subject. Chapter I. deals with the experimental methods employed by the author, including the determination of solubility, lowering of freezing-point, rise of boiling-point and electrical conductivity. Details regarding all the precautions employed are given. Chapter II. is concerned with the conditions of equilibrium in a system of two bodies, the following typical cases being studied in detail: (1) β-naphthol and benzene; (2) β-naphthol and picric acid; (3) triphenyl-methane and benzene; (4) picric acid and benzene; (5) ammonia and ammonium nitrate. The following tables contain some of the results of these experimental investigations:—

1. β-Naphthol and Benzene.

Temperature	121	112·5	106·5	95·3	89·8	87	77·4	71·5	67	32·5	12
Molecules of $C_{10}H_7OH$ in 100 molecules of mixture	100	79	71·6	51·8	44·8	39·3	25·1	17·8	14·6	3·6	1·83

2. β-Naphthol and Picric Acid.

Temperature	122·2	117	120·2	146	151	156·4	150·8	136·4	127	117	121
Molecules of picric acid in 100 molecules of mixture	100	95·6	85·4	70·2	62·9	51·4	35·2	23·1	12·4	4·87	0

3. Triphenyl-Methane and Benzene.

Temperature	87·3	83·5	77·6	77·1	73·2	74·7	71	60·6	52·1	40	24·5
Molecules of triphenyl-methane in 100 molecules of mixture	89·7	82·1	73·5	59	49·7	32·5	26·8	15·1	10	4·86	1·97

4. Picric Acid and Benzene.

Temperature	122·2	111	95·1	88·8	85·6	83·8	77	67	40·4	15	10
Molecules of picric acid in 100 molecules of mixture	100	84·5	63·2	56·6	51·9	48·8	37·6	20·2	7·59	2·1	1·7

5. Ammonia and Ammonium Nitrate.

Temperature	168 (about)	109·8	94	68·8	33·3	0	−10·5	−34	−44·5	−60	−80 (abou
Molecules of NH_4 NO_3 in 100 molecules of $NH_4NO_3+NH_3$	100	78·2	67·3	53·8	45·8	38·3	36·9	30·9	13·9	6	0

Chapter III. deals with the conditions of equilibrium in a system of three bodies, the particular substances studied being picric acid, β-naphthol and benzene, and a method of representing the experimental results by a three-dimensional model being explained. In Chapter IV. is considered the application of the law of mass action to the study of equilibrium in a triple system. Chapter V. is devoted to a consideration of the effect of a solvent on the progress of a reaction, and contains a simultaneous application of the law of mass action and the phase rule to this problem. A. H.

236. *Melting-Points of Mixtures of Optical Antipodes.* **M. Centnerszwer.** (Zeitschr. Phys. Chem. 29. pp. 715–725, September 15, 1899.)—The author has investigated the following series of mixtures:—d- and i- dimethyl tartrate; l- and i- methyl mandelate; d- and l- tartaric acid; l- and i- isobutyl mandelate; l- and i- mandelic acid; d- and l- chlorsuccinic acid; d- and l- camphoric acid; d- and i- chlorsuccinic; d- and l- isocamphoric acid; d- and l- benzyl-aminosuccinate; d- and l- aminosuccinic acid; d- chlorsuccinic and l- bromsuccinic acids; i- chlorsuccinic and l- bromsuccinic acids. In all except two cases the "normal" results are obtained, *i.e.*, when melting-point as ordinate is plotted against composition as abscissa, the curves show one maximum and two *break-minima*. This means that in these cases racemic compounds are stable under the conditions of the experiment and no solid solutions are formed. In two cases a different behaviour was observed. The curves for the two mixtures, d- and i- dimethyl tartrate, d- and l- tartaric acid, show no minima and one *break-maximum*. This indicates the presence of a racemic compound and two series of solid solutions in each case. F. G. D.

237. *Alloys of Platinum and Palladium with Cadmium, Zinc, and Magnesium.* **Hodgkinson, Waring,** and **Desborough.** (Chem. News, 80. p. 185, October 20, 1899. Paper read before the British Association, 1899.) —The more volatile metals were brought in contact with the platinum or palladium in the form of vapour. Platinum gave $PtCd_2$ as a white, crystalline, very brittle substance which does not lose weight when heated to redness *in vacuo*. With zinc, the alloy contained 45 per cent. of Zn, much of which volatilised at a red heat *in vacuo*, leaving PtZn (24·45 per cent. Zn) as a crystalline, very brittle mass. Magnesium gives a friable, crystalline alloy, approximating to the formula $PtMg_3$. Palladium shows practically no tendency to take up either cadmium or zinc vapour. Nickel behaves similarly. T. E.

238. *Fifth Report to the Alloys Research Committee.* **W. C. Roberts-Austen.** (Instit. Mech. Engin., Proc. 1. pp. 35–68. Discussion, pp. 68–102, February, 1899.)—In the present experiments a new differential recording pyrometer is used to study the phenomena of recalescence in the cooling of iron. Two galvanometers are used, one of the sensitiveness hitherto employed, the other much more sensitive. The platinum-iridium wire of the thermal junction, which is inserted as usual in the iron under examination, passes through a bored platinum cylinder in close proximity to, and therefore at the same temperature initially, as the iron. A second junction with the platin-iridium is made within the mass of platinum, and the thermal current here generated is opposed to the equal and opposite current from the first couple. The sensitive galvanometer is so connected that it fails to indicate so long as these opposing currents are equal, but as soon as recalescence occurs in the iron the equilibrium is destroyed and a reading is obtained

of the rise of temperature independent of the actual temperature at which it occurs. This latter reading is obtained from the less sensitive galvanometer, which traces the record of the cooling of the whole mass. Electro deposited iron examined with this arrangement showed recalescence points at 1,132° C., at 895° C. (the Ar_3 of Osmond), and at 766° C. (Ar_2). The Ar_1 point, as expected, was absent, there being no carbon present; but evidence of heat-evolution was obtained at a point between 550° and 600° C., again between 450° and 500° C., and yet again at 261° C. (slight). It is suggested that the 487° point represents the separation of a hydride of iron from solid solution in the mass of iron, and the 261° point the corresponding eutectic point, as both points are nearly obliterated after the iron has been repeatedly heated *in vacuo*, and are restored by recharging it with hydrogen by making it the negative electrode in acidulated water. The greater portion of the remainder of the report is devoted to the production of evidence in favour of carburised iron being a solid solution, the analogy of cryohydrates, and the evidence of the mechanical properties of various steels and of the microscope being dwelt upon. The application of photo-micrography to the examination of iron and steel from the scientific and technical points of view is described, and a large number of micro-photographs illustrating the structure of the metal are given in the paper, and by some of those taking part in the discussion. W. G. M.

239. *Disintegration of Platinum and Palladium Wires.* **W. Stewart.** (Phil. Mag. 48. pp. 481–484, November, 1899.)—That incandescent wires are gradually disintegrated has been proved, among other methods, by Lodge's experiment which shows that air freed from dust recovers its cloud-forming capacity after glowing a wire in it. In hydrogen such a wire does not disintegrate. Nahrwold supposed that oxygen is required for the disintegration of platinum or palladium. The author has confirmed this by a number of experiments made at various pressures, and has incidentally found that the disintegration decreases as the glowing is continued. Thus, in one set of experiments the same platinum wire was used six times consecutively, each experiment lasting two hours and the temperature of the wire being the same in each. The loss of weight gradually decreased from 0·68 per cent. to 0·11 per cent. of the weight. For palladium the same rule was found to hold good. The amount of disintegration was the same whether the air was moist or dry. On exhausting the space in which the wires glowed, the disintegration of platinum decreased, while that of palladium increased. We have therefore not to deal with an ordinary process of combustion, though Kaufmann has shown that disintegration is more rapid in pure oxygen. The actual process going on cannot as yet be said to be very clear. E. E. F.

240. *Electrical Determination of Saturation-point of Solutions.* **H. M. Dawson** and **P. Williams.** (Zeitschr. Elektrochem. 6. pp. 141–144 August 31, 1899.)—The method has already been described by J. H. van' Hoff. (See 1899, Abstract No. 1937.) In this paper the results of experiments on Glauber salts and sodium sulphate are given. The temperature specific conductivity curves of saturated solutions of these two salts ar almost parallel straight lines in the regions where the respective solutions ar stable, but at about 30° C., where the transformation begins to take place, th curve for Glauber salts bends over towards the temperature axis and cu the sodium sulphate straight line at about 32·6° C. Similar experiments a described with thorium sulphate in place of sodium sulphate. With th

thorium salts the amount of salt in concentrated solutions is much less than with the sodium salts. The curves obtained are approximately straight lines inclined to each other at about 90° and intersecting at the temperature 48° C. This transition temperature was tested also by the dilatometer, which gave 46·5° C. A tensimeter method, in which the point of equality of vapour pressures of the dry salt and its saturated solution is determined, gave between 47° and 48° C. J. B. H.

241. *Energy of Carbon and Voltaic Action.* **C. J. Reed.** (Elect. World and Engineer, 34. pp. 231-233, August 12th; 271-273, August 19th; 308-309, August 26th; and 342-343, September 2nd, 1899.)—After enunciating fundamental principles of voltaic action, the author considers the possibility of voltaically oxidising carbon by means of oxides, and thus converting its energy *directly* into electric energy. From thermal considerations it appears that only a few oxides are available, and of these the oxides of copper, bismuth, nitrogen, and sulphur are the only ones which are found in nature, and are wholly reducible. None of these, however, are capable of competing with the steam engine on account of their cost. Oxides which are partially reducible are likewise unavailable. The author then discusses indirect methods. The problem is not to find a solvent for carbon, but to find a process by which carbon may transfer its energy to a suitable substance from which the energy may be subsequently liberated voltaically. Such a process takes place in every primary battery, but the efficiency is much too low to compete with the steam engine. Several such efficiencies are calculated. W. R. C.

242. *Theory of Lead Accumulators.* **M. Mugdan.** (Zeitschr. Elektrochem. 6. pp. 309-320, December 7, 1899.)—Although the theory of the lead accumulator as a reversible element is pretty firmly established, there is general confusion with regard to the chemical processes taking place in the cell, and the views of Darrieus (see 1898, Abstract No. 1356), which are irreconcilable with the theory, are still accepted by many. According to this investigator, the PbO_2 of the positive plate is reduced to PbO during the discharge, whilst lead suboxide is formed at the negative plate, and the production of lead sulphate is regarded as due to secondary reactions; the peroxide produced in charging is held to be the result of the oxidation of the sulphate by persulphuric acid. The experiments described in the present paper were undertaken with the view of reconciling the physical and chemical investigations of the action of the cell. Contrary to the views of Darrieus, it is found that even with high current densities, rapid discharges, and dilute electrolytes, *i.e.*, under conditions least favourable to sulphating, lead sulphate, and at most only very trifling quantities of oxide, is formed on both plates. In short, lead, lead peroxide, and lead sulphate are the only substances concerned in the discharge of the accumulator.

By means of analyses before and after discharging in circuit with a copper voltameter, it is shown that with 10 per cent. sulphuric acid, a current density of 0·02 amperes per square centimetre, and a discharge lasting twenty minutes, lead sulphate is formed on both plates in practically the theoretical amount. When sodium sulphate solution is substituted for sulphuric acid, oxide is formed at the positive plate, but sulphate to the extent of 70 per cent. of the theoretical amount is produced at the negative electrode. In a second series of experiments the plates were discharged in normal sulphuric acid, thoroughly washed, digested with a known quantity of normal acid, and t

amount of acid absorbed subsequently determined by titration. The results show no evidence of the production of oxide, except at the positive plate when sodium sulphate was used instead of acid in the discharge, and are in full agreement with the view that sulphating is a primary, and not merely a secondary process. These results are confirmed by experimental determinations of the curves of anodic and kathodic polarisation, of which diagrams are given. It is also shown that persulphuric acid, which is formed in trifling quantity in charging under normal conditions, exerts no oxidising action on lead sulphate, as required by Darrieus's theory; on the contrary, it deoxidises lead peroxide.

Experimental confirmation is adduced of Dolezalek's theory that the E.M.F. of the accumulator depends only on the concentration of the electrolyte, and it is pointed out that the changes in the E.M.F. during charging and discharging are due to variations in the resistance of the cell brought about by the influence of sulphating and local variations in the concentration of the electrolyte. The influence of acid concentration on the E.M.F. of the electrodes taken separately is finally discussed, and the theoretical deductions shown to be in accordance with experiment. N. L.

243. *Paraanisaldoximes.* **H. R. Carveth.** (Journ. Phys. Chem. 3. pp. 437–451, October, 1899.)—α-Paraanisaldoxime melts at once at 62·8°, and in 55 minutes at 61·0°, but does not melt at 58·9° in 135 minutes. β-Paraanisaldoxime melts in 30 seconds at 134°, in 155 seconds at 124·5°, in 6 minutes at 117·1°, and in 2 hours at 89·5°. This variation in melting-point is due to the fact that both isomerides undergo isomeric change, and pass in the fused state to a condition of equilibrium. The stable triple-point at which the solid α-oxime is in stable-equilibrium with the fused mixture is 54·20°; the entectic-point lies about 0·2° lower and represents the freezing-point of a mixture containing a slight excess of the β-oxime as compared with the normal state of equilibrium in the fused mixture.

The addition of hydrochloric acid converts both oximes completely into the hydrochloride of the β-oxime. The reconversion of the β-oxime into the stable α-oxime takes place gradually by heating it either alone or with a solvent, and is indicated by the lowering of the melting-point; this falls to 118° by heating with alcohol at 100° for an hour, and to 86° by heating for 2¼ hours; 3 hours' boiling with toluene lowers the melting-point to 111°, 70 minutes' boiling with toluene to 127°, and 2 hours' boiling with acetone to 62°. As the isomeric change takes place most rapidly in acetone and least rapidly in toluene, the latter is the best solvent to use for recrystallising the β-oxime. T. M. L

244. *Dissociation of Gases.* **R. Wegscheider.** (Akad. Wiss. Wien S.ber. 108. pp. 69–81, 1899.)—Under constant external pressure and at uniform temperature the proportionate number of gramme-molecules dissociated is, when there is an infinite dilution with one of the products of dissociation, the square of what it is when there is no such dilution; that is, when the products of dissociation are two in number. For intermediate conditions the proportion dissociated is intermediate; and no amount of dilution with one of the products will altogether prevent dissociation from taking place. If the dissociation-reaction be that n_0 gramme-molecules break up into n_1, n_2, . . . &c., gramme-molecules, there are three cases: (1) $n_0 - (n_2 + n_3 + \text{\&c.}) < 0$, where n_1, the missing n, is that corresponding to the product of which an excess is added: in this case the dissociation

at infinite dilution with the product of dissociation, is complete; (2) $n_0-(n_2+\&c.)=0$, in which case the proportion between the dissociated and undissociated at infinite dilution with one product is—

$$\sqrt[n_0]{\left\{\left(\frac{n_1}{n_0}\right)^{n_1}\cdot\frac{a^{n_1+n_2+\&c.}}{\left(1+\frac{n_1}{n_0}a\right)^{n_1}\left(1-a\right)^{n_0}}\right\}}$$

where a is the proportion dissociated when there is no dilution; and (3) $n_0-(n_2+\&c.)>0$, in which case an excess of a product completely checks dissociation. Examples of these three cases: (1) [not given: *qy.* ammonia gas diluted with nitrogen?]; (2) carbonic acid diluted with oxygen: $2\,CO_2=O_2+2\,CO$; $n_0=2, n_2=2$; $n_0-n_2=0$; the dissociation has a definite value at all dilutions with oxygen; hence no excess of oxygen will enable carbonic oxide to become thoroughly burned into carbonic acid; and where the proportions dissociated without dilution with oxygen were 0·01, 0·1, 0·3, 0·5, 0·7, 0·9, respectively, the corresponding dissociations at infinite dilutions with oxygen would be 0·0007, 0·024, 0·134, 0·309, 0·548, and 0·834, so that the restraining effect of the addition of oxygen rapidly falls off as the original tendency to dissociation increases; (3) carbonic acid diluted with carbonic oxide: $2\,CO_2=2\,CO+O_2$: $n_0=2, n_2=1$; $n_0-n_2>0$; a considerable excess of carbonic oxide will completely prevent dissociation. Under constant volume on the other hand, an excess of one of the products will restrain, and an infinite excess will completely prevent dissociation. When a reaction in a dilute solution is associated with a change in the osmotic pressure, there is on further dilution a change in the equilibrium such as tends to increase the osmotic pressure, and thus acts in a sense opposed to the dilution. The presence of phosphorus trichloride does not completely prevent the dissociation of phosphorus pentachloride: some 3 to 10 per cent was dissociated in Wurtz's experiments. A. D.

245. *Uranyl Salts.* **C. Dittrich.** (Zeitschr. Phys. Chem. 29. pp. 449–490, 1899.)—The electrolytic conductivity and freezing-points of solutions of a number of uranyl salts and of mixtures of uranyl and sodium salts are measured, also the solubility of uranyl oxalate in sodium oxalate solution and some thermochemical data. Qualitative experiments show that the uranium migrates to the anode when solutions of sodium uranyl acetate (concentrated), propionate, oxalate, tartrate and citrate are electrolysed. It is shown that in these cases complex anions containing the UO_2 radicle are formed. In most uranyl salts UO_2 is the kathion. The details are mainly of chemical interest. T. E.

246. *Liquid Mixtures with Minimum Boiling-points.* **J. H. Pettit.** (Journ. Phys. Chem. 3. pp. 349–363, 1899.)—The following statement is submitted to experimental examination: If the vapour-pressure curves of two liquids which are miscible in all proportions intersect, then some mixture of the liquids has a maximum or minimum boiling-point. Mixtures of chloroform and methyl alcohol have a minimum boiling-point at about 90 per cent. of chloroform, mixtures of acetone and methyl alcohol have a minimum at 86·5 per cent. of acetone, mixtures of ether and methyl alcohol have neither a minimum nor a maximum boiling-point. In the two first cases the vapour-pressure curves intersect; in the last case they do not. Fourteen other cases of minimum boiling-points are collected from existing sources, and where vapour-pressure curves are available they are shown to follow the

rule. The converse is also true as far as data are available. The composition of the vapour evolved from mixtures of acetone and methyl alcohol is determined, and the application of the results to the practice of fractional distillation pointed out. T. E.

247. *Chemical Equilibrium and E.M.F.* **H. Danneel.** (Zeitschr. Elektrochem. 6. pp. 293–295, November 28, 1899.)—The author considers the reaction, $M_1+M_2X \rightleftarrows M_1X+M_2$ where one metal partially displaces another equi-valent metal from a solution of one of its salts. Regarding the dissociations as complete, the equilibrium may be written : $M_1+\overset{+}{M}_2=\overset{+}{M}_1+M_2$. By a somewhat roundabout method the author arrives at the following result (*cf.* Nernst and Ogg) : The ratio of the solution-tensions of the two metals is equal to the corresponding ionic concentrations when equilibrium is attained in the above reaction.

Putting $M_1=Ag$, $M_2=H$ and $HX=HI$, we have $Ag+\overset{+}{H}=\overset{+}{Ag}+H$, and—

$$\frac{P_H}{P_{Ag}}=\frac{[\overset{+}{H}]_0}{[\overset{+}{Ag}]_0}$$

where the P's denote solution-tensions and the suffixes 0 indicate equilibrium-values of the ionic concentrations. Considering AgI to be completely dissociated in solution, and putting its solubility in mols.$=a$, we have *for any* solution with solid AgI present, $[\overset{+}{Ag}]\,[\overset{-}{I}]=a^2$. In a solution containing any appreciable quantity of HI we may put $[\overset{+}{H}]=[\overset{-}{I}]$, and so we get finally—

$$[\overset{+}{Ag}]_0=\frac{a^2}{[\overset{+}{H}]_0}$$

and therefore—

$$\frac{P_H}{P_{Ag}}=\frac{[\overset{+}{H}]_0^2}{a^2}.$$

The author obtains the value of $\frac{P_H}{P_{Ag}}$ from the known E.M.F. of a silver-hydrogen cell in which the ionic concentrations of silver and hydrogen are equal, and the value of a^2 from the solubility-measurements of Specketer and Goodwin. In this way he calculates $[\overset{+}{H}]_0=0{\cdot}057$ at 18° C. His own actual determination of $[\overset{+}{H}]_0$ gave 0·042 at 18° C. In view of the difference in temperature, and the uncertainty of the solubility-data for AgI, the agreement is regarded by the author as satisfactory. F. G. D.

248. *Electrolytic Potential and its Application.* **A. Schükarew.** (Zeitschr. Phys. Chem. 29. pp. 726–729, September 15, 1899.)—The author introduces into the theory of conducting solutions a function ϕ, the "electrolytic potential," defined by the equation :—

$$\phi=\left(\frac{\delta U}{\delta \lambda}\right)_{T,S,p,v,m,\ldots,\mu\ldots}$$

Where $U=$*inner energy* of system, $\lambda=$its electrolytic conductivity, T temperature, $S=$*entropy*, $p=$pressure, $v=$volume, $m=$mass of a component,

μ = Gibbsian chemical potential of a component. Following Gibbs's thermodynamical method the author then proceeds to deduce the "dilution-formula :—

$$\frac{\operatorname{Log} v_0 - \operatorname{Log} v}{\operatorname{Log} \lambda_0 - \operatorname{Log} \lambda} = \kappa$$

which he shows to hold well for solutions of acetic acid.

[It is necessary to remark, however, that the author's theory contains the assumption $d\mu = Kd\phi$, for which he gives no justification.] F. G. D.

249. *Conductivity of Aqueous Solutions of Potassium Magnesium Sulphate.* **T. C. McKay.** (Elektrochem. Ztschr. 6. pp. 111–115, September, 1899.)—A series of experiments was made to ascertain whether the conductivity of solutions of the double sulphate of potassium and magnesium could be calculated on the assumption that the salt is decomposed into potassium and magnesium sulphates by dissolution in water. With solutions of the double salt containing from 0·4 to 1 gramme—equivalent per litre the conductivity is less than that calculated for the separate salts, but with more dilute solutions the reverse is the case, although the differences are small. It is concluded that in dilute solutions the double sulphate suffers decomposition, but that in strong solutions the two constituents remain united. N. L.

250. *Conductivity of Aqueous Solutions of Alkali Chlorides and Nitrates.* **F. Kohlrausch** and **M. E. Maltby.** (Preuss. Akad. Wiss. Berlin, S. ber. 36. pp. 665–671, July 20, 1899.)—The authors seek to attain a higher degree of accuracy than has yet been reached, especially with the more dilute solutions, by using reliable electrical standards and thermometers, by special care in the manipulation of the electrical measurements, by employing salts and water, purified with unusual care, and by paying great attention to the accurate determination of the concentration of the solutions.

The new determinations give numbers which are somewhat smaller than those previously accepted as the most accurate, especially in the most dilute solutions where differences of ½ to 2½ per cent. are found.

The results show that up to and including the concentration 0·002 gram. mol. per litre, the law of independently mobile ions is exactly true ; in more concentrated solutions this is not the case. The diminution of the equivalent conductivity with increasing concentration is roughly proportional to the square root of the equivalent conductivity. T. E.

251. *Ionisation of Good Electrolytes.* **H. Euler.** (Zeitschr. Phys. Chem. 29. pp. 603–612, September 15, 1899.)—That salts do not follow Ostwald's dilution law may be due (*a*) to invalidity of the equation $a = \mu_r/\mu_\infty$; (*b*) to invalidity of the law of mass-action.

(*a*) The equation $a = \mu_r/\mu_\infty$ assumes that the mobility of the ions is independent of the concentration. The loss of mobility due to the greater viscosity of more concentrated solutions is too small to account for the differences observed. There is no reason to assume a hydration of the ions, increasing with dilution, which might affect the mobility, because the active mass of the water is practically constant in moderately dilute solutions. The electrostatic charges of the ions may possibly affect their mobility.

(*b*) The law of mass-action refers, strictly, to the osmotic pressures of the reacting substances and not to their concentrations. It is very possible that the osmotic pressure of an ionised substance is smaller than that which would correspond to its concentration. An attempt to test this view failed. If the

ionising power of a solvent increases with the number of ions in solution owing to increased polymerisation (see 1899, Abstract No. 1940), the effect should decrease as the temperature rises, and Ostwald's law should be more nearly true at high than at low temperatures. Measurements of the conductivity of KCl and $AgNO_3$ show that the precise opposite is the case. The author finally falls back on the assumption of a "change of the ionising power of the solvent by the dissolved salt." T. E.

252. *Ionisation of Sulphuric Acid.* **W. Starck.** (Zeitschr. Phys. Chem. 29. pp. 385–400, July 28, 1899.)—It is probable that sulphuric acid is dissociated, in aqueous solution, into the ions H, SO_4, and HSO_4, and that the relative quantity of the last increases with the concentration of the acid. If this is true, the migration constant for the anion (n), calculated on the assumption that SO_4 ions alone are formed, should increase with the concentration. Determinations of the migration constant in acids containing from 0·29 to over 81 per cent. of H_2SO_4 show that this is the case, the values of n increasing from about 0·2 to 0·64. The values of n also increase considerably with rising temperature.

Contrary to Bein's statement (see 1899, Abstract No. 1284), the values of n obtained in apparatus containing diaphragms of parchment paper or porous porcelain are smaller than those obtained in apparatus without a diaphragm. T. E.

253. *Calculation of Depression of Freezing-point.* **E. H. Archibald.** (Chem. News, 80. pp. 46–47, July 28th; 57–59, August 4th; 68–69, August 11th; and 76–77, August 18, 1899. Transactions of Nova Scotian Institute of Science, vol. 10, 1898-99.)—The object of the experiments was to test the values of ionisation coefficients obtained by J. G. MacGregor's graphical method in the case of a mixture of solutions of two electrolytes with a common ion, by employing them in the calculation of the depression of the freezing-point. Solutions of potassium and sodium sulphates were employed. In the conductivity determinations it was found that the temperature coefficient for potassium sulphate diminished with increase of dilution, the reverse being the case with sodium sulphate. The ionisation coefficient of potassium sulphate increases slightly with rise of temperature, but in the case of the sodium salt it diminishes. Depressions of freezing-point were measured by the method of Loomis, and results were obtained agreeing well with Loomis's. The observed and calculated values for the depression in the case of the simple solutions agreed closely. The calculations for the mixtures were made by the following formula, due to MacGregor:—

$$\Delta = 1{\cdot}86(1 + a_1 + a_2)N/2.$$

(a_1, a_2 are the ionisation coefficients and N the gr.-equivalents per litre.) Th calculated and observed results showed an equally good agreement. W. R. C

254. *Electrolytic Solution-pressure.* **R. A. Lehfeldt.** (Phil. Mag. 4 pp. 430–433, November, 1899. Paper read before the British Associatio September 20, 1899.)—The electromotive force between a metal and a electrolyte, as given in Nernst's well-known form, is—

$$E = \frac{RT}{\epsilon}\log_e\frac{\pi}{P}$$

The values obtained by Le Blanc for the electrolytic solution pressure from the observed values of the E.M.Fs. vary from $9{\cdot}9 \times 10^{+18}$ atmosphe

for zinc, to $1\cdot5\times10^{-36}$ atmospheres for palladium, numbers which it is difficult to accept as representing physical realities.

The author introduces another objection. If an electrical double layer is formed between the metal-plate and the ions in solution near it, a tension is set up between the two. The amount of this tension is $2\pi\sigma^2/D$, on the assumption that the electricity is distributed in two layers of equal surface density σ, D being the dielectric constant of the medium. Also $\sigma=\epsilon x$, where $x=$ number of gramme-equivalents of metal per square centimetre of surface which have gone into solution. Substituting, for the case of zinc (D=80 for water) we get—

$$x=1\cdot27 \text{ grammes},$$

which is obviously not the case. J. B. H.

255. *Photographic Study of Cells.* **R. R. Ramsey.** (Phys. Rev. 9. pp. 189–190, September, 1899.)—Töpler's *Schlierenapparat* may be used for the study of the actions within the electrolytic cell. Every change of density is indicated by a darkening or brightening of the field. The author reproduces some photographs obtained with the current passing up or down through the liquid. E. E. F.

256. *Luminous Phenomena in Electrolytic Cells.* **F. Eichberg** and **L. Kallir.** (Akad. Wiss. Wien., S. ber. 108. pp. 212–219, 1899.)—When alternating currents are passed between two aluminium or magnesium plate electrodes in dilute acid solutions, or solutions of some salts, a continuous luminous glow is seen all over both electrodes, slightly greater in intensity nearer the edges of the plates than at the centres. With continuous currents the phenomena are somewhat different. A clean aluminium plate as anode becomes luminous at the moment of making the current, but very quickly loses the luminosity. A similar plate as kathode does not become luminous. An aluminium plate which has been used as anode becomes luminous when used as kathode in very dilute acid or in water; but in stronger acid solutions, and in solutions of caustic potash, alum, and copper sulphate no luminosity is detected. When both electrodes become luminous the relative intensities depend on the concentration of the solution.

In order to find to what particular part of the period of the alternating current the luminosity is due, the electrodes were examined stroboscopically, the stroboscopic disc being driven by a motor running off the same alternating current mains. By this means each part of the electrode is only visible at one particular phase of the current. The alternate light and dark spaces then seen show that each electrode is lighted up once during each half period. J. B. H.

257. *Electrolytic Evolution of Gases.* **W. A. Caspari.** (Zeitschr. Phys. Chem. 30. pp. 89–97, October 18, 1899.)—This investigation was undertaken with the view of determining the minimum E.M.F. at which gas bubbles are evolved in the electrolysis of acid solutions. The phenomena at the two electrodes are considered separately, the electrodes being in separate vessels A and B, connected by a capillary tube. The vessel A is similarly connected with a third vessel C, which contains a large electrode of platinised platinum, the part above the solution being surrounded by an atmosphere of hydrogen. The electrode in B is fixed and is a large plate of platinised platinum, while the electrode in A is altered in the different experiments and is of wire. The

E.M.F. is applied to A and B, and is increased until bubbles are seen on the electrode in A. The difference of potential between the A and C electrodes is then measured. Theoretically this should be zero when A is kathode, and 1·08 volts when A is anode. Owing to the evolution of gas it is always greater than these values, the excess E.M.F. varying with the metal of the A electrode, with several other conditions. A table of Caspari's results was given in the Abstract No. 1941 (1899). The general results of the experiments are :—

1. With platinised platinum electrodes in acid solution, a visible evolution of gas begins first of all with from 1·55 to 1·56 volts, at ordinary temperatures and pressures.

2. The evolution of hydrogen on platinised platinum is practically a reversible phenomenon, and the theoretical E.M.Fs. are obtained. Other metals require an *excess* E.M.F.

3. This *excess* E.M.F. is increased by great current density, but is little influenced by the nature of the surface of the electrodes.

4. The *excess* E.M.F. is the deciding factor in the chemical evolution of hydrogen from the interaction of metal and acid, making the evolution possible with some metals and not with others.

5. The deposition of bromine and of iodine on platinum fulfils the conditions of reversibility.

6. Silver is deposited from complex salts, also as a reversible phenomenon in spite of very low ion concentration. J. B. H.

258. *Velocities of Ions in Electrolysis.* **O. Masson.** (Zeitschr. Phys. Chem. 29. pp. 501–526, July 28, 1899.)—This paper starts with a review of the history of the subject, which the author divides into three parts: the Hittorf, the Kohlrausch, and the Lodge and Whetham parts. He criticises the several experimental methods adopted by these investigators, and also the application of their experimental results to the theory. He then describes his own method, and shows how in it all the factors in the general equatio

$$C = A\frac{n}{\eta}(U+V) = A\frac{n}{\eta}\pi x(u+v)$$

are measurable, so that his experimental results should really test the theor or rather should test the assumptions on which the theory is built.

He adopts Lodge's plan of making his electrolytes stiff with gelatine. long straight tube is filled with the hot solution of electrolyte and gelatir and the solution is allowed to cool and stiffen in the tube. Any soluti projecting beyond the ends is then cut off. This tube is made to conn two large flask-shaped vessels through stoppered openings in their sid Each of these vessels contains a large plate electrode, and the ves containing the anode is filled with a solution having a coloured ani ($CuSO_4$), and the other is filled with a solution having a coloured kath ($K_2CrO_4 + K_2Cr_2O_7$).

The current circuit is made, and a time record taken of (1) the current, the E.M.F. between the electrodes, (3) the progress of the coloured kath along the tube, (4) the progress of the coloured anion along the tube. It shc be stated that these coloured ions should be so chosen that their veloci are less than those of the corresponding ions in the electrolyte in the t otherwise the advance of the coloured ions will not be sharply defi The advance of the colour is taken by means of graduations on the tube. experiment was finished when the two colours met. The ratio of the len

of the coloured columns is constant and gives the ratio u/v for that particular concentration, while the rates of growth of these coloured columns give the actual values of U and V for the particular potential gradient. Since the uncoloured part of the electrolyte in the tube remains always of the same concentration and of the same specific resistance (since the temperature is kept constant), the falling off in the current must be due to the increase of resistance of the coloured parts. The potential gradient in the uncoloured part must be proportional to its length and to the current; and its actual value can be obtained from one measurement of the resistance.

The results of experiments with a number of different electrolytes are given in tabular form in the paper, and are applied to test the above equation with fairly satisfactory results, the greatest discrepancy being with $MgSO_4$, which gives with different concentrations the ratios between the two sides of the equation as from 0·942 to 0·807 instead of unity. The variations in this ratio with the other salts experimented with, are from 8 per cent. above unity to 5 per cent. below. J. B. H.

259. *Action of Electric Currents upon Ferments.* **F. J. Möller.** (Ind. Électrochim. 3. pp. 63-64, 1899, from "Revue de Chimie Industrielle," p. 169, 1899.)—The author gives brief notes relating to the work of Hermite, Oppermann, Prochownik, Hall, Sommer, Schwartz, Burri, Foth, d'Arsonval and Charrin, Kruger, Spilker and Gottstein, and of himself in connection with the investigation of this subject.

He then describes some investigations by Duclaux upon vinous fermentation, and states that this chemist has found that alternating currents of low E.M.F. can be used to hinder the development of objectionable or foreign ferments in the "must" or "wort." This method is in actual operation in an Austrian alcohol factory. Aluminium electrodes are used, with an alternating current of 0·10 to 0·20 amperes per square decimeter, and an E.M.F. of only 3 volts. Continuous currents may be used; but in this case thermal and chemical effects are also obtained at the electrodes, which are not conducive to the attainment of the desired results. J. B. C. K.

260. *Action at the Aluminium Anode.* **K. Norden.** (Zeitschr. Elektrochem. 6. pp. 159-167, September 7th, and 188-202, September 14, 1899.)—This paper, a great part of which is mainly of chemical interest, is described as a contribution to the electrolytic transformation of alternate into direct currents (Compare 1898, Abstracts Nos. 207, 1358), and the first part consists of a critical and historial account of the researches of Woehler, Buff, Beetz, Graetz, Pollak, Wilson, and others, on the abnormal behaviour of the aluminium anode. The second part is devoted to an exhaustive quantitative study of the cell, and full details of the electrical measurements and chemical analyses are given in the paper. The film which forms on the surface of the anode is shown to be a mixture of aluminium hydroxide and basic sulphate with a little silica and metallic aluminium; it plays an important part in the action of the cell, which is considered to take place thus. The oxygen resulting from the secondary decomposition of the sulphuric acid forms, with the co-operation of the water of the electrolyte, a layer of aluminium hydroxide on the anode. This is at first attacked by the sulphuric acid and enters into simple, chemical solution; the aluminium sulphate thus formed round the anode reacts with the hydroxide thereon and converts it into basic sulphate, which is again transformed into the normal sulphate by the sulphuric acid of the electrolyte. At those parts of the anode where the

metal is exposed through solution of the layer of hydroxide the oxygen atoms give up their charge and either escape in the gaseous state or are employed in forming new layers of hydroxide which are then acted on as previously described. The hydroxide which enters into simple chemical solution is nevertheless to be considered in reckoning the work done by the current, since its formation from the aluminium is brought about by the oxidising action of the current. The transmission of the current by the cell is unintelligible if the anode film be regarded as insoluble, and in the case of electrolytes, such as neutral salts, which are less favourable to the solution of the basic salt the resistance to the current is much increased. Hence the use of neutral or alkaline solutions, as suggested by Pollak, is more advantageous for the rectification of alternate currents than that of dilute sulphuric acid.

N. L.

261. *Disintegration of Metallic Kathodes.* **G. Bredig** and **F. Haber.** (Ind. Électrochim. 3. p. 75, July, 1899, from Bull. Soc. Chim. 3. 12. p. 257.)—An anode of platinum and a kathode of lead, the latter consisting of thread freshly cut and only touching the surface of the electrolyte (40 per cent. sulphuric acid) with an E.M.F. of about 24 volts, cause a disintegration of the lead which diffuses round the kathode. By breaking and making, this phenomena is maintained, which otherwise ceases to manifest itself. The more dilute the acid and the greater the E.M.F. employed, the more marked is the effect, resulting in local fusion of the kathode on the surface. $Cr_2O_7K_2$ in small quantities, however, obviates this result. With the employment of a caustic electrolyte this disintegration is still more marked. The lead thus precipitated is extremely active, and by the employment of a solution of K_2CO_3 and gassing with CO_2, white lead is formed; but the cost of productio[n] would prevent the commercial application of this method.

Other metals disintegrated in alkaline solutions are Hg, Th, Bi, As, S[b] whereas Zn, and Cd, and the other more infusible metals do not show th[e] reaction. In an acid solution only Bi and Pb are affected in this manner.

The authors explain this phenomenon by the formation of metalli[c] hydrides and their fusibility, and in the case of lead by the lesser or greate[r] displacement of the metallic kathode surfaces previously investigated b[y] Haber. The disintegration is not accompanied by luminous effects and therefore unlike the arc, the discharge in Geissler tubes and the incande[s]cence of metallic filaments.

O. J.

262. *Nature of Zinc Sponge.* **F. Foerster** and **O. Günther.** (Zeitsc[h]. Elektrochem. 6. pp. 301–303, November 30, 1899.)—In a former paper (s[ee] 1899, Abstract No. 151) the authors expressed their opinion that the produ[c]tion of zinc sponge is due to disturbance of the crystallisation of the metal [on] the kathode by the separation of zinc hydroxide or of basic zinc salts. [It] was therefore expected that the use of alkaline solutions, in which zi[nc] hydroxide is readily soluble, would obviate the production of spongy zi[nc] and the first experiments in this direction seemed to show that this was [the] case. Further experiments have shown, however, that although fine, coher[ent] deposits are at first obtained by the electrolysis of solutions of zinc oxide [in] caustic soda, yet after a short time, usually less than an hour, the format[ion] of a spongy deposit is observed, especially when the agitation of the liq[uid] is insufficient. Variation of the temperature from 20° to 50°, or of the cur[rent] density from 0·02 to 0·09 amperes per square centimetre, has little influe[nce] on the results. The zinc sponge is formed more rapidly and more abunda[ntly]

in dilute than in strong solutions. Similar results were obtained with alkaline lead solutions, but no sponge appears to be formed if ammonia, instead of potash or soda, is used in the electrolysis of solutions of zinc and cadmium.

These results show that the views previously expressed require modification, but it may be stated generally that the production of zinc sponge is associated with the liberation of hydroxyl ions and a proportionately small concentration of zinc ions. N. L.

263. *Electrolytic Baths.* **Q. Marino.** (Elektrochem. Ztschr. 6. pp. 97–99, August, 1899.)—The use of glycerin instead of water as a solvent in electrolytic processes is attended with great advantages. This liquid is neutral, miscible in all proportions with water and alcohol, and dissolves most substances which are soluble in water; it opposes little resistance to the migration of the ions, and wasteful secondary reactions are obviated by its employment. Various illustrations are given of the general availability of glycerin in electrolysis. N. L.

264. *Dissolution of Iron Anodes in Sodium Acetate and Acetic Acid.* **G. Arth.** (Ind. Électrochim. 3. pp. 83–84, August, 1899; Bull. Soc. Chim. 21–22. p. 766.)—A number of experiments were made on the electrolysis of an aqueous solution containing 5 per cent. of sodium acetate and 5 per cent. of acetic acid, the kathode being a platinum cylinder and the anode a pure iron plate 50 mm. long, 12–15 mm. broad, and about 2 mm. thick. Using a current of 0·10–0·36 amperes at 0·79–1·35 volts, the iron dissolves as *ferrous* acetate in an amount corresponding with that required by Faraday's law, whilst at higher voltages and under conditions which are yet undetermined the theoretical quantity of *ferric* acetate is formed. In some experiments, moreover, the iron was observed to assume an almost "passive" condition, only a small quantity of ferric acetate being formed. In connection with these results some observations of Wohlwill (see 1898, Abstract No. 684) on univalent and tervalent gold ions are referred to. (Similar results in the case of chromium have been obtained by W. Hittorf. See 1898, Abstract No. 1,072, and 1899, Abstract No. 1744.) N. L.

265. *Electrolytic Reduction of Nitro-derivatives.* **P. Pierron.** (Ind. Électrochim. 3. pp. 84–86, August, 1899; Bull. Soc. Chim. 21–22, p. 780, 1899.)—The nitro compound is dissolved in a mixture of alcohol and sulphuric acid, and electrolysed between a platinum anode and nickel kathode, using a kathodic current density of 0·4–0·75 amperes per square decimetre. At the ordinary temperature the nitro-derivatives of the paraffin hydrocarbons yield substituted hydroxylamines, but at 70° C. further reduction occurs, and the corresponding amines are principally formed. N. L.

266. *Reducing Action of Electrolytically separated Metals.* **A. Binz** and **A. Hagenbach.** (Zeitschr. Elektrochem. 6. pp. 261–271, November 2, 1899. Read before the 71st Meeting Deutscher Naturforscher und Aerzte zu München.)—The reducing action of metals in the presence of water is commonly attributed to the nascent hydrogen evolved therefrom, but it is well known that the effect produced depends on the source of the hydrogen, that is, on the metal from which it is evolved or at which it is liberated in electrolysis. Various explanations of this fact have been suggested, and the present paper, much of which is of chemical interest only, commences with a brief historical account of these. Former investigations (see 1899, Abstracts

Nos. 153 and 154) on the electrolytic reduction of indigo having indicated that the zinc used as the anode played an important part in the reaction, further experiments on the electrolytic reduction of indigo and other organic colouring matters in alkaline solution have been made with the following results. The results previously obtained with indigo are confirmed. The ease with which the colouring matters are reduced by sodium and potassium amalgams increases as the quantity of hydrogen evolved therefrom decreases, and the reduction is not effected to the same extent by the equivalent quantity of hydrogen, the difference being greatest when the hydrogen is electrolytically evolved at a low current density. Zinc, when deposited on a mercury kathode from its solution in caustic alkali, reduces more quickly than an equivalent amount of hydrogen at a low current density. Reduction is also effected by zinc and lead when these metals are deposited on a mercury kathode from solutions of their acetates. These results lead to the conclusion that the colouring matters investigated, although reduced by nascent hydrogen, are much more quickly reduced by the direct action of sodium, potassium, and zinc. N. L.

267. *Electrolysis of the Bromides of the Alkaline Earth Metals.* **J. Sarghel.** (Zeitschr. Elektrochem. 6. pp. 149–158, September 7; and 178–188, September 14, 1899.)—In this paper a detailed account is given of a large number of experiments on the electrolysis of aqueous solutions of the bromides of calcium, magnesium, and barium. The electrolysis was carried out between platinum electrodes in a closed cell, without a diaphragm, placed in a bath of constant temperature, and provided with arrangements for the collection of the gases evolved; the bromine existing as bromate and hypobromite was determined by analysis after each experiment, the electrolysis being continued in every case until the yield became sensibly constant. The influence of variations in concentration, in temperature, and in the current density and E.M.F. was also studied. As regards calcium bromide the final yield of available bromine increases with the temperature until a certain limit is reached which lies at about 90° for 10 per cent., and at a somewhat lower temperature for 20 per cent. solutions. Above these limits the yield decreases, on account of increased reduction. With low current densities the yield is smaller in concentrated than in dilute solutions; high current densities favour reduction and the formation of hypobromite. The reduction is decreased by raising the current density at the kathode, but increased by raising it at the anode. Addition of free alkali (lime) favours reduction and formation of hypobromite and consequently lowers the yield. The condition of the kathode is an important factor in the electrolysis. A rough surface favours the production o bromate since the lime deposited adheres to the kathode; whilst a smoot surface is advantageous to the formation of hypobromite, because the lime i not deposited on the kathode but remains suspended in the liquid, and there fore produces the same effect as the addition of free alkali. The yield c bromate is greater with calcium than with potassium, bromide, and the cours of electrolysis is essentially different, as was to be expected from th comparative insolubility of lime.

In the case of magnesium bromide a larger amount of hypobromite and smaller amount of bromate is formed than is the case with calcium bromid and the final yield is notably less. This was found to be due to the escape bromine, since the solution does not contain enough of the very sparing soluble magnesium hydroxide to combine therewith. A rise of temperatu favours the production of bromate, and thus increases the yield. Contrary

what is observed with calcium bromide, high current densities, up to a certain point decrease the reduction and decomposition of water, and therefore increase the yield. The same effect is produced by increased current density at the anode or kathode alone. Addition of alkali increases the yield by preventing escape of bromine; a large excess, however, decreases the yield.

With barium bromide, owing to the greater solubility of barium hydroxide, a lower yield is obtained than with calcium and magnesium bromides. As with potassium bromide, the yield is decreased by a rise of temperature.

N. L.

268. *Electrolysis of the Alkali-Metal Chloride Solutions.* **H. Wohlwill.** (Zeitschr. Elektrochem. 6. pp. 227–230, October 5, 1899.)—This contribution to the theory of the electrolytic chlorate cell must be read in conjunction with previous contributions by Wohlwill (see 1899, Abstract No. 341), and by Foerster (see 1899, Abstract No. 1946) on the same subject.

The correctness of the "ionic equation" given by Wohlwill in the former when applied to the formation of chlorate in neutral or slightly acid solutions, has been disputed by Foerster. Foerster maintains that in such solutions the chlorate is the result of a secondary reaction between free hypochlorous acid and $\overline{ClO}$ ions. Wohlwill now replies to this by quoting the results of experiments which, in his opinion, prove that $\overline{OH}$ ions may be formed in both neutral and slightly acid solutions; and by showing that in such solutions it is probable that both primary and secondary reactions occur during the formation of chlorate. J. B. C. K.

269. *Electrolysis of the Alkali-Metal Chloride Solutions.* **F. Foerster.** (Zeitschr. Elektrochem. 6. pp. 253–256, October 26, 1899.)—This contribution is a reply to that of Wohlwill (see preceding Abstract). In this latest contribution to the discussion, Foerster maintains the correctness of his criticism of Wohlwill's theory of the chlorate cell, and reasserts his opinion that in neutral or slightly acid solutions, the formation of chlorate is chiefly due to secondary (chemical) and not to primary (ionic) reactions. J. B. C. K.

270. *Electrolysis of Ammonium Thiosulphate.* **P. Pierron.** (Chem. News, 80. pp. 73–74, August 18, 1899; from Bull. Soc. Chim. 3. 21. No. 10.)—The aqueous solution of ammonium thiosulphate, containing 17·5 per cent. of the anhydrous salt, was placed in a porous pot in which a cylindrical platinum electrode was suspended; the other electrode, of lead, surrounded the porous pot and was placed in a 10 per cent. ammonium carbonate solution. The temperature was maintained at about 15° throughout the experiments. In the first experiments, the platinum was used as the kathode and a current density of 10 to 40 amperes per square decimetre was employed. Under these conditions reduction occurs, and ammonium sulphide appears to be the sole product. If the inner electrode is the anode the reactions are much more complex; sulphur is deposited, sulphurous anhydride is given off, and the liquid becomes acid from the formation of sulphuric, trithionic, and tetrathionic acids. Small quantities of pentathionic acid are formed in the early stages but are subsequently destroyed by oxidation; hydrogen sulphide was not detected. The formation of free sulphur and sulphuric acid increases with the anodic current density (3–40 amperes per square decimetre), whilst the amount of tetrathionic acid *decreases; little variation* is noticed in the sulphurous and *trithionic acids. In explanation of* these facts it is suggested *that the $SO_3.S.NH_4$ ions first formed split up into* sulphur, sulphuric acid, and

ammonium sulphate. The latter then itself undergoes electrolysis, forming sulphuric acid and oxygen, which converts a portion of the thiosulphate into tetrathionate. N. L.

271. *Electrolysis of Solid and Melted Electrolytes.* **C. C. Garrard.** (Zeitschr. Elektrochem. 6. pp. 214–216, September 28, 1899.)—The object of these experiments was to determine the E.M.F. at which electrolysis begins in melted electrolytes. The electrolytes were melted in a glass tube in a bath of molten lead and the current was passed between two carbon electrodes. A series of gradually increasing E.M.Fs. were applied to the electrodes and the corresponding currents measured. The resistances were simultaneously measured by Kohlrausch's method and from these the corrections to be applied to the product of current and E.M.F. were determined. The results were then plotted and the sharp bend in the curve gave the desired point at which the electrolysis started or increased.

In some salts two distinct points of dissociation were well marked corresponding to two different degrees of dissociation analogous to the similar dissociation of water; into the ions HO and O and then H_2 and O. The salts which showed two distinct dissociations were, PbI_2, $CdCl_2$, $CdBr_2$, CdI_2, the E.M.Fs. at which these occurred being in the case of PbI_2 0·896 and 0·705 volt at 495° C., and in $CdCl_2$ 0·715 and 1·225 volt at 568° C. In some of these cases the first dissociation satisfies the condition of reversibility as given by Helmholtz, but not the second, analogous to the two dissociations in water. The haloid salts of Ag, K, and Na have only one point of dissociation and it satisfies the condition of reversibility. J. B. H.

272. *Commercial Electrolytic Generation of Oxygen and Hydrogen.* **W. S. Franklin.** (Amer. Electn. 11. pp. 526–527, November, 1899.)—The electrolytic generator for oxygen and hydrogen made at the Lehigh University is an improved form of that made in the laboratory of the Iowa State College in 1895–6. It is made of cast iron frames insulated with hard rubber, the frames serving as electrodes. The electrolyte is a solution of caustic soda. The gases are kept separate by means of sheet iron baffles set one above the other in a slanting position. The apparatus is fully described with drawings. The tests carried out by H. J. Horn and P. Bucher with this apparatus show that the water may be separated into its two constituent gases, each being of 99·9 per cent. purity, due care being given to the current density and adjustment of the baffle plates. The electrical efficiency proved to be 41 per cent.

The cost in the improved cell is not given, but in the old one it was 1 cent per cubic foot of oxygen, the current costing 2 cents per kw. hour.

J. L. F. V.

273. *Electrolytic Bleaching of Wood Pulp.* **A. Navarre.** (Ind. Électrochim 3. pp. 49–51, 1899.)—At the works of Bergès and Corbin, the Hermite process with its many platinum and zinc electrodes and heavy currents at abou 6 volts, was given a trial in 1890. In order to avoid dynamos of speci design and corrosion of electrodes, Corbin has adopted the following arrange ment at Lancey: The trough contains two electrodes at the ends, an eleven intermediate insulated electrodes, all fixed in frames fitting in tightly the plates are all of platinum and the intermediate plates serve as doubl electrodes. The connecting cables are fixed outside the trough, and b varying the number of intermediate plates, any tension may be applie The thirteen plates at Lancey receive currents of 150 amperes at 120 volt

The electrolyte is sea-salt solution, and the process continuous. Each cell can bleach 750 kg. of bisulphite pulp to extra whiteness. H. B.

274. *Electric Tanning.* **J. Bose.** (Ind. Élect. 8. pp. 344–348, August 10, 1899.)—The author refers to the use of the electric current for promoting the absorption of chemicals by living tissues, and argues from this that electricity must prove of equal service in accelerating the permeation of skins and hides by tanning materials. Grosse in 1849 first employed galvanic action for this purpose; and he was followed by Ward in 1859, Rebu in 1861, de Meritens in 1874, and by Gaulard and Kresser in 1885. Leather tanned by the last-named process was exhibited in London in 1885. In 1889 the methods of Worms and Ballé and of another unnamed inventor, were experimentally tried in London and Paris. The author obtained specimens of leather tanned by the latter process, and found that it wore well when made up into shoes.

The two processes, together with those of Groth and of Burton, are described in some detail, and figures are given relating to voltage, current density, and to the saving of time effected by their use. The Groth process is said to have been in operation in London, in Belgium, and near Lausanne. The Burton process has been tried in America. J. B. C. K.

275. *Electric Tanning.* (Indus. and Iron, 27. p. 83, August 4, 1899.)—Four to twelve months is the time usually taken to tan ordinary sole leather. Groth claims to have reduced this time to one-fifth, and the cost to two-thirds, by his electrolytic method of tanning. The daily absorption of tannic acid by the ordinary process is stated to be 0·183 grm., as compared with 2·08 grms. in Groth's process.

Tests of the finished leather (five weeks' tanning) made by Unwin gave remarkably high results. And equally satisfactory tests were obtained by Parker of the Leatherseller's Company. Details of these are given.

The Groth process is said to be at work in Sweden and Norway, the patents in these two countries having been bought by the Wenersborg Leather Industry Co. J. B. C. K.

276. *Cost of Calcium Carbide.* **F. Liebetanz.** (Zeitschr. Elektrochem. 6. pp. 117–122, August 10, 1899.)—This is a report of an address delivered at the second Buda-Pesth Acetylene Congress in May, 1899. The author seeks to answer the question as to the relative economy of gas-, water-, and steam-power, when used for carbide production on a small scale; it being assumed that the difficulties and costs of distributing carbide will limit the area of effective competition from the factories established at the great centres of water-power.

The estimates are based upon the power and raw materials required for 1,000 kgs. carbide, and the yield of carbide per kw. day of twenty-four hours is taken as 5 kgs.

The gross H.P. necessary to yield 1,000 kgs. carbide per day is therefore 340, or allowing for all losses in the generating machinery, 450.

Taking these figures as the basis of his calculations, the author arrives at the following results for a 450 H.P. plant :—

	Water-fall.	Steam.	River-flow.
Capital outlay	£6,750	£2,800	£3,750
Annual running charges	£675	£1,464	£1,000
Daily running charges	£2 5s. 0d.	£4 18s. 0d.	£3 7s. 0d.
Cost of 1 E.H.P. year at the electrodes of furnace	£2 10s. 0d.	£5 8s. 0d.	£3 14s. 0d.

Adding to these costs of power, the cost of raw materials and labour, the total costs for the production of 1,000 kgs. carbide by the three sources of energy named above, work out to—

Water-falls	£8 18s.
Steam	£11 14s.
River-flow	£9 15s.

The author gives no detailed estimates for the cost of carbide with gas-power, but he is of opinion that the use of blast-furnace gases for this purpose will undergo great development in the near future. J. B. C. K.

277. *Memmo Carbide Furnaces at San Marcel.* **C. Pio.** (Elect. World and Engineer, 34. pp. 195–198, August 5, 1899.)—This works operates with three-phase currents. Some of the facts mentioned in the paper have already received notice (see 1899, Abstract No. 1412). The present article gives useful detailed drawings of the furnace, and its electrical conductor connections, with some notes upon the method of working at San Marcel.

J. B. C. K.

278. *Calcium Carbide Industry at Merano.* (Elettricità, Milan, 18. pp. 406–408, 1899; also Éclairage Électrique, May 6, 1899.)—The hydraulic works of the Gesellschaft Etschwerke, in the Austrian Tyrol, near Merano, are briefly described. They contain five turbines of 1,200 H.P. each direct coupled to three-phase alternators generating current at 10,000 volts. Of this 2,000 H.P. is sold to the Acetylene Gas Co. at 47s. 6d. per H.P. year. For the carbide furnaces the current is transformed down by six three-phase transformers of 260 kw., each giving 2,500 amperes per phase at 88 volts. One phase of each of three of the transformers are connected in parallel for each furnace. The lime is obtained locally in the form of a very pure marble. The furnaces, on the system of Gin and Leleux, are described. They yield 11·4 lbs. of carbide per kilowatt hour, giving 4·8 cubic feet of acetylene per lb. The cost of the carbide is estimated at £7 9s. per ton. L. B.

279. *Polyphase Electric Furnaces.* **R. Memmo.** (Elettricità, Milan, 18. pp. 438–441, 1899.)—In electric furnaces acting merely by heat and not by electrolytic action, alternating offer great advantages over continuous currents. A furnace consisting of several arcs in parallel cannot be run satisfactorily owing to the impossibility of regulation. And the size of single carbon electrodes, and hence the power of a continuous current or monophase furnace is limited. In this direction polyphase currents offer great advantage, the power of the furnace being increased by simply increasing the number of phases up to 20 or 30. They may be arranged in mesh or in star—the latter being preferable, as the arcs have less reaction on each other– the molten mass being employed as the neutral point. This system has also the advantage that one or more of the phases may be employed for lighting or other purpose without interfering with the work of the furnace. L. B.

280. *Experimental Electric Furnace.* **S. A. Tucker.** (Amer. Electn. 11. pp. 408–409, September, 1899.)—A brief account of Moissan's and other electric furnaces for use on a small scale, with a table giving the names, formulæ, discoverers, and certain properties of various carbides formed in such furnaces. W. G. M.

281. *Magnetic Ore Separators.* **E. Langguth.** (Zeitschr. Elektrochem. 6. pp. 321–324, December 7, 1899.)—This paper contains a historical review of the development of the method of separating ores according to their relative magnetic permeabilities. J. B. H.

282. *Manufacture of Liquid Air.* (Eng. News, 41. pp. 368–371, June 8, 1899.)—This paper is a description, with general view and diagrammatic sections of the various parts of the liquid air manufacturing plant of the General Liquid Air and Refrigerating Co., New York City.

It is estimated to produce 1,500 gallons of liquid air per day. It consists of a steam-power refrigerating plant, utilising the expansion of the compressed air to produce a low temperature, and causing this cold air to react upon itself, until the temperature is so low that liquefaction occurs.

Steam is raised at 150 lbs. pressure by three vertical fire-tube boilers, each of 75 nominal H.P. The steam drives four-stage air-compressors connected by intercoolers. Sectional views are given of the cleanser to take the dust out of the air previous to compression, and of the separator for removing oil, moisture, and other impurities from the air after compression, also of the liquefier and after-cooler with details of their valves and coils. The inter-cooler and after-coolers extract the heat generated by compression, by passing the air over water-cooled tubes. The air, at a pressure of 1,200 lbs. per square inch, and at 50° or 60° F. the temperature of the brine tank, passes to the liquefier coils and through the contracted orifice of the expansion valve adjusted to throttle the flow, and is reduced in pressure from 1,200 lbs. to 300 lbs. per square inch. The drop in temperature so produced is repeated by the cumulative cooling process until the critical temperature of air is reached. Then a portion of the air passing through the expansion valve liquefies and collects in a small reservoir over the after-cooler, and the other part passes into the cooling tubes and is used over and over again. Fresh air is drawn in through the cleanser to take the place of that liquefied. A sectional view and description is also given of a reservoir for storing and carrying the liquid air so that it can be retained in a liquid form. W. R.

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283. *Primary Batteries.* **W. R. Cooper.** (Electrician, 43. pp. 601–602, August 18, 1899. Historical Notes.—(Pp. 700–702, September 8, 1899) Theory of Grotthus applied to a simple voltaic cell.—(Pp. 800–803, September 29, 1899) Thermal relations in the voltaic cell.—(Pp. 877–880, October 13, 1899, and pp. 916–918, October 20, 1899) Chemical and Contact Theories.

284. *Dissociation Pressure before H. Sainte-Claire Deville.* **P. Duhem.** (Journ. Phys. Chem. 3. pp. 364–378, 1899.)—Historical.

285. *Electrolytic Treatment of Sulphide Ores.* **S. Cowper-Coles.** (Electrician, 44. pp. 81–83, November 10th. Abstract of paper read before the Society of Engineers, November 6th.) Brief descriptions of various systems, including those of Watts, Diffenbach, Ashcroft, Siemens-Halske, Hoepfner's, Mohr's, Swinburne's Processes.—Pp. 111–113, November 17th) Description of the Author's Process.—(Pp. 157–159, November 24th. 1899) Zinc sponge.

286. *Applications of Electro-metallurgy to Mechanical Engineering.* **S. Cowper-Coles.** (Electrician, 44. pp. 50–51, November 3, 1899.)—Abstract of a paper read before the British Association.

287. *Electrolytic File Sharpening.* **S. Cowper-Coles.** (Elect. Rev. 45. pp. 704–705, November 3, 1899.)

STEAM PLANT, GAS AND OIL ENGINES.

288. *Steam Engines for Electric Traction.* **C. A. Hague.** (Eng. Mag. 18. pp. 425–430, December, 1899.)—Probably the steam engine has never been called upon to do work of so variable a character as that of developing power for a street railway, and in selecting a type of engine for street railway work the extreme variation of load is a factor of great importance. With a plain slide-valve engine controlled by a throttling governor the widest range of work affects the steam economy but slightly; with the compounds, triples and quadruples the expected economy, due to limited range of cylinder temperatures, cannot be closely realised except by keeping nearly to ideal conditions for the particular type in hand. In a railway power plant, owing to the variations of load, the choice of the steam engine lies somewhere between a naturally wasteful engine whose economy cannot be easily injured and a very economical type whose best economy cannot be maintained. This choice seems to point to the cross-compound condensing engine for units of 1,000 H.P. and upwards. The average steam consumption in a traction power house of simple non-condensing, cross-compound condensing, and triple condensing engines may be represented by the figures 180, 125, and 150 respectively, the steam consumption for each type of engine under a steady load being taken at 100. The question of storage batteries and triple expansion engines is sometimes raised, but the interest and maintenance accounts prevent their adoption for large plants for railway power. Cheap money and dear fuel may possibly lead to a readjustment of conditions.

The question of speed and voltage regulation is discussed, and it is pointed out that, while the electrical engineer requires a constant voltage with varying power, the cotton spinner requires uniform speed with varying power.

The author discusses the regulation of the steam engine by throttling the steam for very short cut-off, and in combination therewith varying the point of cut-off further out in the stroke with full initial pressure. The general statement of the problem of the steam engine for electric traction is sufficient to indicate its peculiar difficulties. A. S.

289. *Experiments upon Engine Governors.* **W. G. Hibbins.** (Instit. Civ. Engin., Proc. 137. pp. 376–401, August, 1899.)—The characteristic speed curve from a governor, in which the revolutions of the governor are plotted as abscissæ and the lift of the governor sleeve as ordinates, consists of two curves due to the sleeve rising and falling respectively. The difference between the two curves is due to the frictional resistances of all the pieces connected to the sleeve. The author made experiments at Mason College, Birmingham, under the superintendence of R. H. Smith, on Tangye (Soho), Acme, Lüde, Proell, Watt, Porter, Pickering, Turner-Hartnell, and Belliss governors, and obtained speed curves; in the case of the spring loaded governors, different loads were placed on the spring. In a series of speed curves for one governor the mid-position of the sleeve is indicated by a horizontal line drawn across the curves. At the points where this base-line is intersected by any pair of curves the corresponding load or spring-pull is plotted off as a pair of vertical ordinates. By joining the series of points so obtained, two almost parallel straight lines are obtained for all the governors experimented on, the upper one corresponding to the "down" curve, and the

lower one to the "up" curve. From the diagrams the "sensitiveness," "controlling force," and "controlling energy" are easily obtained. The chief results obtained from the nine governors tested are exhibited in a table. As regards the controlling force, the small Tangye governor has a high value; it is, however, lacking in sensitiveness. The Turner-Hartnell governor has a large controlling force, and a large amount of frictional resistance in its working parts. The highest values of the controlling force are exhibited by the governors which have either heavy balls, weights, or heavy central loads. The Proell governor appears to be far superior in sensitiveness to the rest. The Porter governor compares favourably with some of the more modern types, possessing both sensitiveness and great controlling force.

In a summary of the results arrived at, the author makes the following statements: The controlling force of a governor is increased by increasing the weight of the balls or the central load. The controlling force and sensitiveness are increased by providing the governor with powerful springs. Shaft governors can be made more powerful, bulk for bulk, than vertical governors. The advantages of the more modern types, such as well-designed Watt and Porter governors, are not so great as perhaps might be expected.

A. S.

290. *Fuel Economy of Steam Engines for Traction.* **R. C. Carpenter.** (Street Rly. Journ. 15. pp. 801–804, November, 1899. Paper read before the New York State Street Railway Association.)—The results are given of thirty-five tests of electric railroad power stations made under the ordinary conditions of operation in which the economy is affected to a great extent by variation in load, and by poor or good firing; the latter often makes 20 per cent. or more difference in fuel economy. The steam consumption at normal steady load of 120 I.H.P. by a simple non-condensing automatic slide-valve engine was slightly over 27 lbs. of steam per I.H.P., nearly 30 lbs. at 150 H.P., 44 lbs. at 60 H.P., and 64·3 lbs. at 40 H.P. The average results show a consumption only about 25 per cent. higher than obtained with this class of engine under most favourable conditions, or about 34·3 lbs. of steam and 4·63 lbs. of coal per I.H.P. hour. With non-condensing simple Corliss engines under favourable conditions 23 lbs. to 25 lbs. of steam might be used per I.H.P., while the average of the tests under working conditions, being slightly over one-half of the rated capacity, was 28·3 lbs. per I.H.P. hour.

Reducing test results to uniform evaporation, the compound non-condensing engine was 9·4 per cent. more economical in use of coal, and about 5·5 per cent. more economical in use of steam than the simple non-condensing engine. The compound non-condensing engine under best load conditions would use 22 lbs. to 23 lbs. of steam, or nearly 33 per cent. less than under power-house conditions, but the data for this deduction are limited.

The compound condensing slide valve or high-speed automatic engine uses 15 lbs. of steam under favourable load conditions, but under working conditions the consumption would be 30 per cent. or 40 per cent. more. Compound condensing Corliss, Greene, McIntosh and Seymour and engines having similar valve motions consume 15 lbs. or less with favourable load, which is increased by about 20 per cent. under working conditions. The average boiler evaporation from and at 212° was 10·26 lbs. for stations using simple non-condensing engines, 9·82 lbs. for stations using compound condensing slide valve engine, and 10·54 for stations using compound condensing Corliss engines per lb. of fuel. The estimates of the cost of plant are exclusive of real estate, buildings, and chimneys, and the estimates

of working expenses do not include wages and oil. The author concludes from the tests that compound condensing slow speed engines with improved valve gear are much the better investment.

Summary of Tests.

No.	H.P. of Engine.	Steam per I.H.P. Hour.	Actual Coal per I.H.P. Hour.	Mean Observed I.H.P.	Per Cent. Observed HP. to Capacity.	Boiler Evaporation per lb. Combustible from and at 212°.	Kind of Coal.
SIMPLE NON-CONDENSING SLIDE-VALVE ENGINES.							
6	200	34·8	4·47	110	55	11·50	Pea A
1	405	34·5	(*a*) 6·54	257	63·4	(*a*) 9·11	Culm, East Ohio
7	1,975	35·7	4·60	862	51	9·46	Bit. W. Pa.
11	300	37·3	4·49	90	44	12·20	Bit.
11	300	34·3	4·72	95	46·7	10·20	Bit. Ill.
24	1,000	31·8	(*b*) 5·38	717	71·7	(*b*) 9·15	Bit.
31(*c*)	270	41·5	(*c*) 5·50	126	47·5	(*c*) 10·60	Ant. Buck.
33	270	31·6	4·61	147	54·5	10·70	Ant. Pea
Average		35·1	5·07	...	54·2	10·24	
Average neglecting (*c*)		34·3	...	...	...	...	
Average neglecting (*a b c*)		...	4·63	...	...	...	

Remarks.—Engine in test (31) in bad condition. Probable average coal per I.H.P. hour, when using anthracite or eastern bituminous, 4·63 lbs.; anthracite culm, 6·54; western bituminous, 5·38. Coal per kw. output averages 50 per cent. higher, or 6·94, 9·81, and 8·07 respectively. Probable error for any given case not over 10 per cent. Steam pressure, 90 lbs. to 120 lbs.

No.	H.P. of Engine.	Steam per I.H.P. Hour.	Actual Coal per I.H.P. Hour.	Mean Observed I.H.P.	Per Cent. Observed HP. to Capacity.	Boiler Evaporation per lb. Combustible from and at 212°.	Kind of Coal.
SIMPLE NON-CONDENSING CORLISS ENGINE.							
17	300	30·1	3·09	139	46	11·45	Clearfield Bit.
19	150	26·9	3·5	90	60	9·73	Ant. Buck.
22	350	28	3·77	153	44·7	8·55	Ohio Bit.
Average		28·3	3·45	...	50·3	...	
COMPOUND NON-CONDENSING ENGINE.							
2	1,000	30·5	4·22	603·5	60·3	9·03	Bit., 3 parts Ant.
4	1,250	36·8	4·33	674	53·8	9·92	Culm, 1 part. Bit. slack
21	400	34·20	4·17	203	51	10·23	Bit. Penn.
24	1,200	30·37	4·93	754	62·7	9·01	Bit. Ill.
Average 21 and 24		32·28	4·55	...	...	...	

Remarks.—Test No. 2 was made on three simple engines 150 H.P., one cross compound 260 H.P. and one triple 300 H.P. Test No. 4 was made on three simple engines 250 H.P. each, and one compound of 500 H.P. Steam pressure, 100 to 125 lbs.

Summary of Tests—*continued.*

No.	H.P. of Engine.	Steam per I.H.P. Hour.	Actual Coal per I.H.P. Hour.	Mean Observed I.H.P.	Per Cent. Observed H.P. to Capacity.	Boiler Evaporation per lb. Combustible from and at 212°.	Kind of Coal.
COMPOUND CONDENSING SLIDE-VALVE OR HIGH-SPEED AUTOMATIC ENGINE.							
3a	600	29·4	4·43	174	29	10·38	3 parts A ; 1 pt. Bit.
3	600	23·2	3·50	190	32	9·93	1 part Bit.
8	400	20·2	3·14	154	38	8·29	Ohio Bit.
8b	400	16·7	2·40	180	45	7·75	Ohio Bit.
13	250	24·6	2·95	86	34·5	10·51	Bit. Penn.
16	350	22·7	3·41	164	47	9·50	Ant. Pea
18	1,200	25·6	3·61	904	75	10·58	Pea Penn.
21	400	29·3	3·81	188	47	10·23	Bit.
Average		23·96	3·41	...	...	9·64	
Average except 3a and 8b		24·26	3·40	...	...	9·82	
Average omitting 3a, 18, 21, and 8b		22·7	3·25	...	...	...	

Steam pressure, 100 lbs. to 130 lbs.

No.	H.P. of Engine.	Steam per I.H.P. Hour.	Actual Coal per I.H.P. Hour.	Mean Observed I.H.P.	Per Cent. Observed H.P. to Capacity.	Boiler Evaporation per lb. Combustible from and at 212°.	Kind of Coal.
COMPOUND CONDENSING, CORLISS, GREENE, MCINTOSH AND SEYMOUR, AND SIMILAR VALVE MOTIONS.							
10	825	22·7	4·06	482	58·2	8·29	½ Bit. Slack. ½ A Culm.
14	1,000	21·9	2·56	277	27·7	10·96	Bit.
14	1,000	20·0	...	314	31·4	10·96	
28	350	16·64	2·10	182	52·2	11·80	Bit.
27	500	16·90	2·61	290	58	9·36	Bit.
30	2,000	14·50	1·80	814	40·7	10·70	Bit.
34	200	17·30	2·91	145	72	11·14	Bit.
35	1,600	20·50	2·18	...	...	11·14	Bit.
Average		18·8	2·60	...	...	10·54	

Evaporation, 7·25 to 1 of coal.

Average omitting No. 10		18·25	2·36	...	...	...	

Evaporation, 7·78 to 1 of coal.

Summary of Average Results.

Class of Engines.	Steam per I.H.P. Lbs.	Coal per I.H.P. Lbs.	Steam per I.H.P. Lbs. Best Load.	Proportional Value of Engine.	Probable Coal per kw., lbs.
(A) *Non-condensing.*					
Slide valve simple, average	34·3	4·63	30	53·1	6·90
Best result	31·6	4·61	...	...	...
Corliss simple, average	28·3	3·45	25	64·5	5·65
Best result	26·9	3·01	...	...	...
Slide valve, compound, average	30·37	4·17	22	60·2	6·12
(B) *Condensing.*					
Slide valve, compound average	22·7	*3·25*	*16*	80·5	4·57
Best result	*16·7*	*2·40*	...	...	3·60
Corliss, compound average	*18·2*	*2·36*	*15*	100	3·64
Best result	*14·5*	*1·80*	...	...	2·70

COST PER H.P. OF 500 H.P. PLANT.

	Boiler H.P. per Engine H.P.	Cost per H.P. in Dollars.					Cost for 500 H.P. Plant.
		Engine.	Boiler.	Pumps and Heaters.	Piping. &c.	Total per I.H.P.	
Non-condensing Engines.							
Simple slide valve	1·135	8·00	13·60	2·00	5·00	28·60	14,300·00
Simple Corliss	0·933	12·00	11·20	2·00	5·00	30·20	15,100·00
Compound slide valve ...	1·00	11·00	12·00	2·00	5·00	30·00	15,000·00
Condensing Engines.							
Compound slide valve ...	0·75	11·00	9·00	4·00	6·00	30·00	15,000·00
Compound Corliss	0·602	16·00	7·25	4·00	6·00	33·25	16,625·00

FUEL AND INTEREST CHARGES FOR THE DIFFERENT CLASSES OF ENGINES.

	Coal per I.H.P. Hour.	Tons per H.P. per Year.			Fuel Cost per Year. 18 Hours per Day. $2 per Ton.	Interest and Depreciation, 8 per cent.	Total Cost per Year per H.P.
		Day. 12 Hours.	Day, 18 Hours.	Day, 24 Hours.			
Non-condensing Engines.					$	$	$
Simple slide valve, average	4·63	10·4	15·21	20·28	30·42	2·29	32·71
" " " best	4·60	10·7	15·10	20·14	30·20	2·29	32·49
Simple Corliss, average...........	3·45	7·55	11·33	15·10	22·66	2·42	25·08
" " best	3·01	6·59	9·89	13·18	19·78	2·42	22·20
Compound slide valve	4·17	9·05	13·57	18·10	27·14	2·40	29·54
Condensing Engines.							
Compound slide valve, average	3·25	7·12	10·68	14·24	21·36	2·40	23·76
" " " best ...	2·40	5·25	7·88	10·51	15·76	2·40	18·16
Compound Corliss, average	2·36	5·17	7·74	10·33	15·48	2·64	18·12
" " best...........	1·80	3·94	5·91	7·88	11·82	2·64	14·46

J. T. R.

291. *Water-tube Boilers for Marine Engines.* **J. T. Milton.** (Instit. Civ. Engin., Proc. 137. pp. 167–201. Discussion, pp. 242–305, August, 1899.)—There is considerable difference between the conditions of work to which boilers are subjected in warships and those experienced in merchant vessels. This accounts for the more ready introduction of water-tube boilers into the former class of vessels. Greater economy and durability are demanded in a water-tube boiler for the merchant navy. After inherent strength of form the essential elements to be provided for are complete combustion, even a high rates and with minimum air-supply, and ready transmission of heat The mean velocity of the hot gases over the heating surface having bee shown to be about 26 feet per second, it follows that no portion of the gases remains in a boiler for more than one second. The arrangement an size of flues may, however, modify this result. The circulation of the wat in boilers, as demonstrated on the basis of experiments by Yarrow, Thorn croft, and Blechynden, does not lead to any definite conclusion as to tl advantage of, or necessity for, a high speed of circulation. The followi water-tube boilers are compared with the "Scotch" boiler and described the paper, viz. :—the Belleville with economiser, Lagrafel-D'Allest, Niclaus

Babcock-Wilcox marine type, Yarrow, Fleming-Ferguson, Reed, Normand, Thornycroft, Blechynden, Mumford and Haythorn—examples of all of them being quoted. The paper concludes with remarks on the importance of treatment, and on the effects of thickness of material, and of curvature of tubes on durability. In the discussion **J. List** stated that in mail-steamer work the limit of steam pressure with tank boilers had practically been reached. They were using double-ended eight-furnace boilers, 17 feet mean diameter and 19 feet 2 inches long, for a working pressure of 210 lbs. per square inch. The boiler shell-plates were $1\frac{3}{4}$ inch thick, and the furnaces were 44 inches internal diameter and $\frac{11}{16}$ inch thick—the steel of the shells having an ultimate tensile strength of between 31 and 34 tons per square inch. Weight of such a boiler with mountings was 115 tons, and the water was $49\frac{1}{2}$ tons additional. Comparing Belleville boilers for similar work at 300 lbs. per square inch pressure, it was found that they had $4\frac{1}{2}$ per cent. less total heating surface than the tank boilers; weighed 40 per cent. less; saved in length of space 13 per cent.; but cost 50 per cent. more in first cost. F. J. R.

292. *Niclausse Water-tube Boiler.* **M. Robinson.** (Elect. Engin. 24, pp. 456–462. Discussion, p. 462, October 13, 1899.)—Compared with the Babcock-Wilcox land type and the Yarrow, Thornycroft, and Belleville marine boilers, the Niclausse boiler possesses features which make it a distinct type. Composed of tubes of 3 to 4 inches diameter, slightly inclined from the horizontal, it has headers only at one end of them, the other end being left free, so that there is no rigidity to resist expansion lengthwise. The free end of the tube is closed with a screwed cap, and the front end is secured by two coned joints to both outer and inner walls or faces of the header, but communicates only with the inner of two chambers or passages into which the header is divided by a partition. The outer passage is in communication with a number of smaller tubes, one of which is inserted concentrically into each of the larger generating tubes, for circulation of water. At the top of the header is the steam drum, and as the water level in it is some distance above the header, circulation commences as soon as heat is applied to the tubes. This does not take place in such boilers as Thornycroft's where the tubes deliver steam above the water-line. The water flows down the outer or downcast half of the Niclausse header, through the small inner tubes, which project nearly the full length of the generating tubes, and back by the outer tubes, the steam and foam escaping by the upcast half of the header. The tubes are connected "in parallel," as in the Babcock-Wilcox boiler, and not "in series," as in the Belleville, so that the circulation is freer than in the latter. The constructive details have been arranged with a view to ease of examination and repair. Originally constructed in France, this boiler has done well in vessels of the navy there and on shore. Since its introduction into the Royal Navy and some electric light installations in England improvements have been made in details. In the trials of the boilers of the *Temeraire*, on land, an evaporation of 11·25, 10·12, 10·72, and 10·3 lbs. of water from and at 212° Fahr. per lb. of coal was obtained with draught of 1·1, 1·5, 2·7, and 4·3 inches of water respectively, the lbs. of steam evaporated per square foot of heating surface having been 4·6, 10·6, 13·2, 15·9 for the different rates of combustion.

Experiments made in Paris on the comparative value for evaporation of the successive stages of tubes in a model boiler showed that nearly $\frac{1}{4}$ of the whole evaporation was due to the first row, and nearly $\frac{1}{2}$ to the first three rows which had 7·5 square feet of heating surface for each square foot of grate.

The first six rows, with a surface ratio of 15 to 1, evaporated nearly ¾ of the whole, and the last, or twelfth, row evaporated only about 8¼ per cent. The value of additional surface can thus be estimated. F. J. R.

293. *Recent Trials of the Machinery of Warships.* **A. J. Durston** and **H. J. Oram.** (Instit. Civ. Engin., Proc. 137. pp. 202–241. Discussion, pp. 242–305, August, 1899.)—In November, 1894, the Engineer-in-Chief of the Royal Navy gave in a paper (Min. Proc. Inst. C.E. 119. pp. 17–46) details of the machinery of the seventy vessels built under the Naval Defence Act of 1889, and the present paper gives similar details of the vessels added to the Navy since that date. In the case of the ten battleships now fitted with water-tank boilers the proportion of heating surface per I.H.P. is increased over former practice on the recommendation of the Admiralty Committee on designs of machinery. The results as to weight are as follows:—

EIGHT VESSELS BUILT UNDER NAVAL DEFENCE ACT.

Mean I.H.P. developed.	Average Steam Pressure. Boilers.	Heating Surface per I.H.P. (mean).	Weight in lbs. per I.H.P. (mean).	
			Engines.	Boilers.
	lbs. per sq. in.	sq. feet.		
11,500	149	1·7	113	116
9,430	150	2·1	146	141

AVERAGE OF TEN BATTLESHIPS BUILT SINCE NAVAL DEFENCE ACT.

12,414	149	2·0	111	131
10,404	148	2·4	132	156
6,170	140	4·1	261	486

Maximum power is obtained in all these vessels by forced draught on t closed stoke-hold system, except in two, fitted with induced draught apparat The I.H.P. developed per ton of machinery is less in the latter than in t former vessels, but the machinery is rather more substantial. The 1st cl cruisers having triple-expansion engines with four cylinders and four cran but fitted with Belleville boilers, without economisers, show:—

I.H.P. developed.	Steam Pressure. Boilers.	Heating Surface per I.H.P.	Weights per I.H.P.	
			Engines.	Boilers.
5,058	216·5	...	...	...
18,479	227·5	3·66	130	140
22,547	231·0	3·00	107	115
25,774	243·0	2·68	94	100

There is a gain in I.H.P. per ton of machinery. In other example warships of the 1st class the steam pressure employed is 300 lbs. per sq inch in the boilers with economisers, engines with four cylinders (tr expansion) are used, and the I.H.P. per ton of machinery amounts to ; *in some instances.* Similar results are given in tables for 2nd and 3rd *cruisers, and for* torpedo-boat destroyers; and a further table (vi.) give *tails of weights and* space occupied for the machinery of four groups of ve

The authors discuss the best number and arrangement of cylinders in the engines; the distribution of power between them; the arrangement of cranks, and the effect of different distributions of the turning moments in production of vibration in the ship, with results obtained. The fitness of various designs of water-tube boilers for special work is pointed out, but on the question of durability, the only definite result as yet reached, is that the life of the boiler tubes of the Belleville boilers will not be less than two commissions. No difficulty has been experienced in working with a boiler pressure of 300 lbs., and an engine pressure of 250 lbs., and the influence of increased pressure on economy of weight and space has been considerable.

F. J. R.

294. *F. H. Smith's System for Gas and Oil Engines.* (Feilden, 1. pp. 366-368, October, 1899.)—The horizontal gas engine invented by F. H. Smith is of the two-cycle type, giving an explosion every revolution, and is designed to occupy small space and have simple mechanism. The exhaust gases are expelled and the new charge drawn in by an *auxiliary piston* during the end of the explosion and the early part of the compression stroke. The engine has no pretensions to ultimate design, and is illustrated by an external view and longitudinal section of a working model, the cylinder only 2½ inches diameter and the stroke 8 inches. An indicator diagram, taken at full load, shows compression 28 lbs. and maximum explosion pressure 132 lbs. per square inch above the atmosphere. The main piston, joined to the crank shaft by a connecting rod, is hollowed out to receive a guide tube fixed to the inner piston next the combustion chamber. Inside the tube there is a strong spiral spring which connects the two pistons and works the inner one. The gas and air inlet port near the crank end of the cylinder is closed and opened by the main piston. During the explosion-stroke the two pistons are forced out together, compressing the spiral spring between them. When the exhaust valve is opened by a lever and cam on the crank shaft, the inner piston is sprung back rapidly, by the compressed spring, to the combustion end of the cylinder, driving out the exhaust gases, and at the same time drawing in the new charge between the two pistons. On the return stroke of the main piston the inlet port is closed and the charge is compressed through the non-return valve in the inner piston into the combustion-chamber. Electric ignition of the charge takes place just before the dead centre, and the explosion drives the pistons out together again.

The inner piston, actuated by the spiral spring, controls the speed of the engine. The amount of the charge drawn in is regulated by the time taken by the inner piston in traversing the cylinder. When the load is suddenly thrown off the engine, though the speed may be momentarily accelerated, the inner piston has not time to complete the full journey to the farther end of the cylinder, and therefore a smaller charge is taken and added to a larger residue of burnt gases as a diluent for a weaker explosion. Consequently the speed gradually slows down automatically.

Only the combustion-chamber end of the cylinder is cooled by a water-jacket. The weak point in the design appears to be the spring which actuates the inner piston. The inventor states that after running for several months the spring in the model had not altered in any way, the cold charge passing round every revolution keeping it cool.

W. R.

295. *Evaporative Condensers.* **H. G. V. Oldham.** (Instit. Mech. Engin., Proc. 2 pp. 185-207. Discussion, pp. 207-254, April, 1899.)—These are

suitable where there is insufficient water for jet or surface condensa condensing water being about one-fortieth that required for surf densing. Tubular principle, steam and water distribution, and variou of condensers are described, and the steam-condensing value of air ci by a fan is given. One square foot of tube surface will condense a m of 8 lbs. of steam and evaporate about 5 lbs. of water per hour. In h wrought-iron tube condensers each square foot should condense fr 4 lbs. of steam per hour.

In the discussion **B. Donkin** thought sufficient attention had paid to the question of dirt on the tubes and in the circulating wa **Longridge** considered there was a great diversity of opinion a amount of surface required. He should say that 35 or 40 square f required per lb. of steam condensed per minute. **L. Andrews** sai Wright condenser had been in use at Hastings electric light st about twelve months without satisfactory results, and described ments to improve the results. **H. B. Spencer** described the Kle cooler, and **C. J. Barley** an oil separator and Ledward condenser results. **W. H. Patchell** thought the general conclusion was cooling water required was equal in weight to the steam condens **Brown** described a condenser for 550 I.H.P. to condense about 1 steam per hour per square foot of surface, occupying 2 square feet space, and weighing 16 cwt. for each 20 lbs. of steam condensed p **H. Boot** wrote of rapid deterioration due to dirt on the tubes. **Oldham** communicated further information and the following tal

WEIGHT OF STEAM CONDENSED PER HOUR PER SQUARE FOOT CONDENSING SURFACE.

Condensers with Horizontal Tubes without Fans.	Lbs. per Hour.	Quantity of Co per Ho
Cast iron plain tubes	1 to 1¼	10 to 1 weight condens
Cast iron plain tubes exposed to good, steady wind	1¼ to 2	
Cast iron corrugated tubes, Ledward pattern	1¼ to 1¾	
Wrought iron galvanised tubes, Fraser design	2 to 2¼	5 to 10 weight condens
Wrought iron galvanised or copper tubes in good position on roof	2¼ to 3	
Condensers with Vertical Tubes.		
Cast iron plain tubes	1½ to 2	10 to 1 weight condens
Brass tubes without fan, and exposed	3 to 3½	
„ „ with fan at slow speed	4 to 5	
„ „ with fan at higher speed and good water circulation	5 to 6	

On wet and windy days the weight of steam is increased 15 to 20 per There are numerous illustrations and diagrams with this paper.

296. *Lepape's Carburetter.* (Automotor Journal, 4. p. 64, Novemb —This article describes one of the new forms of spray-maki *carburetter* now [illegible] developed in preference to the surface

commonly used, more especially for motor cycles. An essential feature is the arrangement by which a cap, forming the exterior of a small air vessel, actuates a pair of small valves in an oil-measuring chamber at each suction-stroke of the motor piston. During the period of no-suction-stroke, oil flows into the measuring chamber past one valve, which is closed by the descent, with the cap mentioned, of the second small valve. The suction by the motor piston withdraws the measured oil, which is disintegrated in its passage from the chamber and its vaporisation completed in its further mixture with air, which is admitted by an adjustable inlet, previous to its mixture with the main body of air on its way to the motor cylinder. W. W. B.

297. *Blast-Furnace Gases for Motive Power.* **H. Allen.** (Feilden, 1. pp. 48-60, August, 1899.)—The author is associated with B. H. Thwaite, the inventor of the Thwaite-Gardner system for the conversion of heat into motion, by the utilisation of the waste gases from blast furnaces in the cylinder of the internal combustion engine.

Whilst 600 to 700 cubic feet of blast-furnace gases burned under steam boilers can develop in the steam engine cylinder 1 I.H.P. hour, the same volume of this gas in a suitable gas engine gives 5 to 7 I.H.P. hours. In this way one I.H.P. hour is developed for every 1·8 to 2 lbs. of fuel charged into the furnace for smelting the iron. In present practice the air blast is heated to 1,200° or 1,400° Fahr. and supplied to the blast furnace at 5 to 10 lbs. per square inch above atmospheric pressure. When coke is used 170,000 to 180,000 cubic feet of gases are given off for each ton of coke consumed, and with raw coal 130,000 cubic feet of gas, measured at 60° F. per ton of fuel. The proportion of combustible gas, carbonic oxide and hydrogen, is higher for coal, and is not dependent always on the weight of fuel required to produce a ton of pig iron. Some furnaces using 28 cwt. of coke per ton of pig iron give off gases poorer in combustible than others taking only 19 cwt. of coke. The poorest gases are from coke-fed furnaces, and the percentage by volume is of carbonic oxide 25 to 35, and of hydrogen about 2 per cent., with marsh gas about 0·5 to 2 per cent. Blast-furnace gas, of heating value 120 British thermal units per cubic foot, when used to drive gas engines, gives one I.H.P. for about 100 cubic feet of gas per hour. This waste gas has been utilised (1) to heat the blast by combustion in hot blast stoves, (2) to generate by steam in gas-fired boilers the power required for the blast, pumping, and hoisting machinery. In the gas engine the gas gives four or five times this power, available for electric distribution.

For instance, it is calculated that in a blast furnace producing 600 tons of pig iron per week, with a consumption of one ton of coke per ton of pig iron, 3·57 tons of coke are used per hour and the gases evolved are 607,070 cubic feet per hour. Allowing one-third of this for heating the blast, and 10 per cent. waste into the atmosphere, this leaves 334,007 cubic feet of gas available for power purposes. At a heating value of 95 British thermal units the gas engine requires 140 cubic feet of this gas per I.H.P. hour, and we have a gas supply equal to 2,386 I.H.P. The blast takes 275 I.H.P., and hoisting absorbs 30 I.H.P., leaving for electric distribution or other purposes 2,081 I.H.P. The waste of gas into the atmosphere might be reduced, and for every 1·8 lb. of coke charged into the blast furnace for smelting the pig iron, under ordinary working conditions, one I.H.P. hour may be developed from the gas evolved.

When boilers are retained for stand-by purposes, the circulating water for keeping the gas engine cylinder cool is available as feed water, and some of

the waste heat is utilised. The blast furnace need not be blown out, but kept in operation continuously for producing power, which may be employed : (1) by gas engines driving air-blowers ; (2) the cleansed and filtered gas can be distributed without any loss due to condensation, as in the case of steam, and used in the gas engine to drive machinery and to generate electric current for light and power.

In the Westphalian iron district in Germany a Thwaite-Gardner plant has been put down to use blast-furnace gas, generating electric current for the manufacture of calcium carbide. The gas from the blast-furnace, after purification, condensation, and filtration, is used to drive a gas engine of 150 I.H.P. The supply of gas is maintained constant by a combined exhauster and blower. The average composition of the gas by volume is :—

Carbonic acid	CO_2	7·8
Carbonic oxide	CO	30·7
Hydrogen	H_2	3·3
Marsh gas	CH_4	0·5
Nitrogen	N_2	57·7
		100·0

The heating value of the gas, down to 212° F., is 111·7 British thermal units per cubic foot at 60° F. The mean pressure in the gas engine cylinder, from the indicator diagram, is 60 to 70 lbs. per square inch. The engine has two cylinders, and at full load there is an explosion every revolution. For small blast furnaces in manufacturing areas the power developed can be disposed of to the best advantage. (See also 1898, Abstracts Nos. 991, 992 and 993.) W. R.

293. *Modern Steam Waggons.* **G. A. Burls.** (Automotor Journal, 4. pp. 53–56. Discussion, pp. 56–58, November, 1899. Read before the Civil and Mechanical Engineers' Society.)—This paper summarises the part of the Locomotives on Highways Act, 1896, which deals with the tare limits for the heavier vehicles. The author proposes that the three-ton limit shoul be raised to four tons, that the gross load per inch width of tyre shoul be as much as two-thirds of a ton, or 1,490 lbs., and that a speed of si miles per hour should be allowed. Incidentally it is remarked that heav load horse waggons which have proved durable at from three to four mile per hour soon give way with the same loads at seven to eight mile per hour. Figures are given, and the power required is calculated, fo "steamobiles" to carry on the four-ton tare limit a useful load of eigl tons, and with assumed road resistances of which tables are given.

The influence of tyre width is dealt with and reference made to the Roy Agricultural Society's trials at Birmingham in 1898 (Rep. Jour. Roy. Ag. Sc vol. ix. part 3, pp. 460–491), experimental figures from which are given.

An analysis is given of all the costs of running a Thornycroft steam wagg for a whole year, doing an average of 34 waggon miles per day, carrying a lo making 110 net ton-miles per day, which in the year amounted to 8,500 mil of running and 27,500 net ton-miles, at a total running cost of 3·1d. per n ton-mile. This is compared with the cost of horse haulage on a large sca which amounts to 6d. per net ton-mile. A table accompanies the paper givi dimensions, results of trials, and cost of running of a large number of Brit and foreign steam vehicles.

In referring to liquid fuel as used in some motor vehicles an express

is given for the quantity of petroleum discharged and burned per hour from orifices, such as those of the Brickford burner, working under different air pressures; it is as follows:—

$$Q = 1050\omega\sqrt{p},$$

Q being oil discharged per hour in pints, ω area of orifice in square inches, and p air pressure in lbs. per square inch. W. W. B.

299. *Renault Motor-Voiturette.* (Indus. and Iron, 27. p. 301, November 8, 1899.)—This article describes a special form of transmission gear which differs from that ordinarily employed in this class of vehicle. It is completely enclosed in an oil-tight gear-case, and the interchanging of the speed gears is effected by the eccentric movement of the shafts carrying the intermediate spur pinions, as in some lathe heads. The reversing gear is also enclosed in this case, and the whole is controlled by one hand-lever and a pedal. The power is transmitted from the speed-gear mechanism, by means of a Hook's joint, to a bevil-pinion, gearing with a bevil-wheel on the exterior of the differential-gear on the rear or driving axle. The carriage is fitted with a 2¾ H.P. de Dion motor, carries two persons, and has run from Paris to Rambouillet, 64·6 miles, in 2 hrs. 49 min. (Eng. Pat. 3981, 1899.) W. W. B.

300. *Acetylene for Autocars.* (Archiv. Post Tele. 11. pp. 555–568, 12. pp. 602–612, June, 1899.)—The author predicts that when safe methods of generating and storing acetylene have been discovered it will displace petrol as the explosive agent in motor-car engines. Acetylene explodes best when mixed with 12 parts of air, whereas the best proportion for coal gas is 6 parts of air. The fuel for 10 H.P. for 100 hours, which in a Serpollet Generator occupies 4 cubic metres, and in a Petrol motor 316 cubic decimetres, only requires 300 cubic decimetres in an acetylene engine. Moreover, acetylene is more cleanly and smells less. Ravel has experimentally found that the efficiency of acetylene is two and a half times as great as that of ordinary coal gas, but he concludes that a type of gas engine suitable for it has yet to be found. Claude and Hesse have shown that, under a pressure of 12 kg. per sq. cm., 1 litre of acetone will absorb no less than 300 litres of acetylene, all of which it will give off again upon lowering the pressure. E. H. C.-H.

301. *W. H. Newman's Variable Speed Gear.* (Engineer, 88. p. 552, December 1, 1899.)—One end of the shaft runs at constant speed, the other is driven at variable speeds within the limits of the mechanism. A spur pinion is fixed to the end of the varying speed shaft, and is set centrally within the case enclosing the gear. Three wheels mesh with this pinion, and each is driven by a roller "free-wheel" clutch. A crank pin is fixed to the disc of each clutch by a limb from an eccentric plate. The eccentric is driven by the constant speed shaft, and the three clutches reciprocate more or less as its throw increases or decreases. The throw of the eccentric is regulated by a hand wheel and screw. No appreciable knock occurs when the gear is running at its highest speed. A. S.

REFERENCE.

302. *Separate Condensing Plants for Factory Purposes.* **A. S. Haslam.** (Instit. Civ. Engin., Proc. 138. pp. 418–420, October, 1899; also Engineer, 87. p. 615.)—Comparison between injection, ejector, submerged or closed surface, and evaporative or open-air condensers. J. T. R.

GENERAL ELECTRICAL ENGINEERING.

303. *Jeanty Primary Battery*. (Elettricità, Milan, 18. pp. 404–406, July 1, 1899.)—This is a battery of the Daniell type with special arrangements for maintaining a constant supply of sulphate of copper. On a trial of thirty-four days' continuous use it consumed 14¼ lbs. of commercial sulphate of copper and 8 lbs. of impure zinc per kilowatt hour, costing 15 pence. It is being employed experimentally to operate a system of electric railway signals by the Chemin de Fer del'Ouest, and for lighting the Paris excursion steamer *le Touriste*. L. B.

304. *Mershon Compensator*. (Amer. Electn. 11. p. 434, September, 1899.)—The object of this device is to obtain correct readings of the feeding-point P.D. in an alternating current network without the use of pilot wires. The arrangement of connections as used by the Westinghouse Co. is as follows. The station voltmeter is joined in series with the secondaries of three transformers. The primary of the first transformer is across the generator terminals. The primary of the second transformer, which has an open magnetic circuit, is joined in series with the feeder. The primary of the third transformer (closed magnetic circuit) is connected as a shunt across a non-inductive resistance also in the main circuit of the feeder. The non-inductive resistance bears the same ratio to the total resistance of the feeder as does the inductance of the primary of the second transformer to the total inductance of the feeder. If everything is properly adjusted, the station voltmeter may under these conditions, be made to read the feeding-point P.D., the open magnetic circuit transformer subtracting from the voltmeter circuit an amount proportional to the inductive drop, and the transformer which shunts the non-inductive resistance an amount proportional to the resistance drop. A. H.

305. *Construction of Resistances*. **M. Levy.** (Elektrotechn. Ztschr. 20. pp. 677–679, September 21, 1899. Report read before the Deutscher Elektrotechn. in Hanover.)—An illustrated description of the manufacture of resistances in which the wire is embedded in enamel, and the heat dissipated by numerous ribs on the cast iron framework. E. K. S.

306. *High-Voltage Condensers*. **Lombardi.** (Ind. Élect. 8. pp. 434–436, October 10, 1899. Abstract of paper read by Lombardi, before the National Congress of Italian Electricians at Como.)—On account of the difficulties connected with their construction, condensers have not hitherto been used for reducing the loss in long transmission lines by providing the idle component of the current at the far end of the line. Lombardi has recently succeeded in constructing condensers whose cost is so moderate as to justify their employment on a commercial scale, and which dissipate so little energy that only a slight temperature rise is observed. The condensers consist of sheets of tinfoil insulated with thin sheets of paraffin (mixed with some other ingredients) prepared by a secret process. A condenser capable of working on a 10,000 volt circuit would have a dielectric thickness of 2 mm. A little over 100 kilogrammes of the dielectric would suffice to produce a capacity of 1 microfarad and the cost of the materials (tinfoil included) would not exceed £14. Experiments carried out by the author have shown that such condensers do not gradually deteriorate when continuously traversed by an alternating current. A. H.

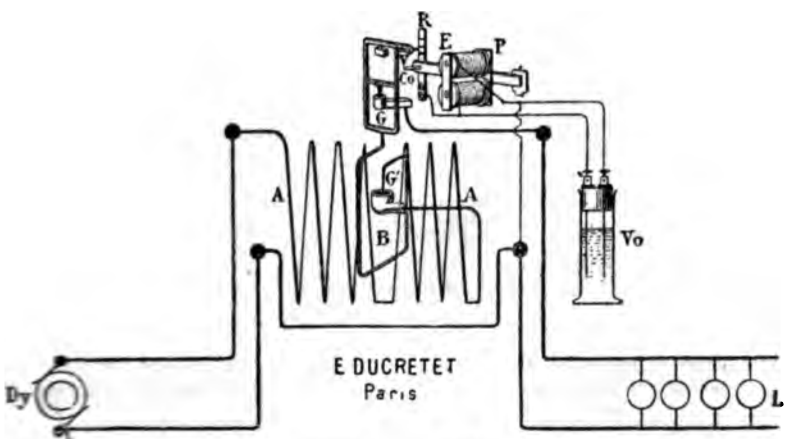
307. *Switches and Circuit Breakers.* **Brunswick, Vedovelli, Zetter, Boucherot, Hillairet, Grosselin, Korda.** (Soc. Int. Élect., Bull. 16. pp. 7–30, and 37–48, 1899.)—These papers form a discussion on the relative merits of various switches for low and high tension circuits.

If interrupters of all kinds are only opened when the current is zero the nature of the metallic surfaces in contacts is immaterial provided the contact is sufficiently good. This is not the case if a current is flowing at the instant of break so as to give rise to sparks or arcs. In this case the choice of the metallic surfaces is a matter of considerable importance. Certain metals and even certain forms of contact surface are better than others in the prevention of the formation of arcs. Recent researches on arcs between metallic electrodes show that certain substances tend to stifle the arc. Zinc tends thus to stifle an arc, as also brass, but to a less extent. For high pressures it is advisable to open switches in oil. W. G. R.

308. *Measurement of Power in Polyphase Systems.* **A. J. Bowie, Jr.** (Elect. World and Engineer, 34 pp. 270–271, August 19, 1899.)—The most common form of three-phase meter at present in use for measuring motor loads is one with a star box. It is not an unusual occurrence for one of the coils of the box to burn out, especially when placed on the wrong side of the switch. In this event the meter will continue to register, since the other coil is alive. If one leg burns out, the meter, if on an induction-motor load, will probably go slightly faster than before; but if the other leg burns out, the meter will slow up very much and in some cases may even run backwards, so that the company will owe the consumer for power which it has furnished.

Meters of this description should be frequently tested to see that both halves of the star box are working. All that is necessary is to see that both legs into the star box spark when disconnected. W. G. R.

309. *Blondlot Meter.* **J. Reyval.** (Écl. Électr. 20. pp. 201–205, August 12, 1899.)—The principle of this meter has already been fully explained in



Abstract 1502, 1899. The present paper contains an illustrated description of the details of construction. The connections of the meter and its principal working parts are shown in the sketch, in which AA represents the fixed and B the movable coil of the meter, G and G′ being the two mercury cups by which the current enters and leaves the suspended coil. E is an

electromagnet whose winding is periodically connected across the supply mains. In order to suppress sparking at the contacts, the magnet is provided with a shunt consisting of a liquid resistance V_0 (two wires dipping into water), V is the contact-arm of the movable coil, and closes the circuit of the electromagnet by coming into contact with the spring R; the latter is normally kept slightly deflected by the spring to which the armature of the electromagnet is attached. When the armature is attracted, the spring R is released, and gives an impulse to the swinging coil. C_0 is an arm attached to the armature and carrying a ratchet which drives the counting mechanism (not shown). The main advantages claimed for the meter are: it is capable of starting with a very small current, the frictional resistance of the counting mechanism not impeding the motion, since the mechanism is driven by the shunt electromagnet; there are no permanent magnets, and therefore no change in the constant of the meter need be apprehended. The constant is adjusted by means of two small movable masses attached to the swinging coil, which enable the moment of inertia of this coil to be varied. A. H.

310. *Alternate Current Meters.* (Ind. Élect. 8. pp. 463–464, October 25, 1899, and Elektrotechn. Ztschr. June 9, 1899.)—In order to encourage a high power factor in a supply system the customers' meters should measure the actual power used together with a percentage depending on the idle current. If ϕ be the lag in a consumer's circuit the power

$$P = EC\cos\phi$$

and the idle current $= C\sin\phi$. In order to charge for a given percentage S of this idle current a meter is required whose angular velocity is not simply $=kP$, but

$$\begin{aligned} &= kEC(\cos\phi + S\sin\phi) \\ &= kP(1 + S\tan\phi) \end{aligned}$$

By suitable design an ordinary alternate current motor meter can be arranged to read this quantity directly. For in such a meter the angular velocity

$$= kP\frac{1+\tan\psi\tan\phi}{1+\tan^2\psi}$$

where ψ is the lag in the shunt or armature coil of the meter. For a given periodicity p, L and R may be so proportioned that

$$\tan\psi = \frac{pL}{R} = S.$$

Then the angular velocity

$$= kP\frac{1+S\tan\phi}{1+S^2}$$

which only differs from the required form in having S^2 in the denominator. This does not affect the readings appreciably if S be less than 10 per cent. In actual meters $S = \frac{pL}{R}$ is less than the value which would be fixed by commercial considerations. If the armature turns were increased till S=5 per cent. the meter would show increased readings by 7 per cent. with a 60 per cent. load factor, 2¼ per cent. with 90 per cent. and 1¼ per cent. with 95 per cent. Such a meter would encourage the use of motors, &c., of high power factor. L. B.

311. *Johnson and Phillips Supply Meter.* (Electrician, 43. pp. 604–606, August 18, 1899.)—This is an intermittently integrating ampere-meter, driven by an electrically operated pendulum. The latter is so arranged that it only receives an impulse when its oscillations diminish below a certain amplitude, by means of a hit-and-miss device; the mean power absorbed is said to be not more than one watt. The meter consists of a fine iron wire sucked into a small solenoid by the main current, and actuating an aluminium pointer; once in 30 seconds the pointer is clamped, a feeler is brought against it, and the integrating mechanism is moved through an angle determined by the position of the pointer. The latter is then freed and allowed to take up a new position, according to the current strength, after which the operation is repeated. The pointer moves over a scale graduated in amperes, and visible from the outside of the instrument. The starting current is said to be $\frac{1}{100}$ of the maximum current, and an accuracy of 1 per cent. at all values of the current is claimed. A. H. A.

312. *Electro Pneumatic Signalling.* (Elect. Rev. 45. pp. 679–682, October 27, and 703–704, November 3, 1899.)—The application of this system of railway signalling in the new Boston Union Station is briefly referred to. The signals and points are worked by compressed air and controlled electrically. The system is also in use in the Bishopsgate Goods Yard, London, on the Great Eastern Railway system. Several photographs of the working details are given. The air valves are worked by a solenoid controlled from the signal cabin. An air pressure of 75 lbs. per square inch is employed. The "levers" consist of short crank handles rotating a long bar to which the various switches are attached as required, giving a much more compact and easily operated system, and a wider range of interlocking connections, than can be obtained by mechanical levers. At the Bishopsgate Yard thirty-eight levers are employed requiring 10 cubic feet of air per minute measured at atmospheric pressure. (See 1899, Abstract No. 1283.) L. B.

313. *Cradle Dynamometer.* **A. F. M'Kissick.** (Amer. Electn. 11. p. 409, September, 1899.)—A description of a transmission dynamometer to measure about 5 H.P. transmitted by a belt from an induction motor to a dynamo. The dynamometer is mounted on two knife edges in line with the axis of the machine. A. S.

314. *Electric Ship-Telegraphs.* **A. Raps.** (Elektrotechn. Ztschr. 20. pp. 645–650. Discussion, pp. 650–651, September 7, 1899; paper read before the Elektrotechn. Vereins, Berlin, February 28, 1899.)—A detailed and fully illustrated description is given of a system of ships' telegraphs actuated by electric currents, constructed by Messrs. Siemens and Halske, and fitted to many ships of the German navy and others. In the discussion **Hefner-Alteneck** briefly described the early forms of electric ship telegraphs and **Arldt** the forms constructed by Elliot Bros. and the Allgemeine Elektricitäts Gesellschaft. L. B.

315. *Insulation for High-Tension Lines.* **C. Hesse.** (Elektrotechn. Ztschr. 20. pp. 623–624, August 31, 1899.)—Description of an ingeniously devised insulator which permits the line wire to be in separate sections between each pair of posts. The wire is supported at its ends by metal hooks or fingers which immediately release it in the event of its being broken. There is thus no danger to life. E. K. S.

316. *Aluminium as an Electrical Conductor.* **C. T. Child.** (Elect. Rev. N.Y. 35. p. 133, August 30, 1899.)—The following constants are taken as basis of the calculations in this article :—

	Copper.	Aluminium.
Conductivity	100	63
Specific gravity	8·93	2·16
Weights for equal conductivity	100	48
Areas for equal conductivity	63	100
Diameters of wires for equal conductivity	10	12·64

The author has calculated from these constants a table showing the equivalent price of aluminium for any price of copper between the two extreme limits of 12 and 20 cents per lb.

This table is also presented in diagram form, with the prices of copper as abscissæ, and the prices of aluminium as ordinates.

The general figures are given below :—

Price of Copper.	Equivalent Price of Aluminium.	Price of Copper.	Equivalent Price of Aluminium.
12	25	17	35·35
13	27·1	18	37·35
14	29·15	19	39·4
15	31·2	20	41·5
16	33·3		

All prices in cents per lb.

The author closes with an expression of his opinion that the use of aluminium for conductors will greatly increase. J. B. C. K.

317. *The Protection of Low-Pressure Circuits from High-Pressure Currents.* **W. B. Reed** and **L. C. Reed.** (Elect. World and Engineer, 34. pp. 649–651, October 28, 1899.)—The methods used at present are classified by the authors : (1) The maintenance of a high insulation on both high-tension and low-tension circuits ; (2) The use of devices to earth, to short-circuit, and to open the affected circuits ; (3) The permanent grounding of one wire of the low-tension circuit.

They point out the objections to these methods, and show by some examples, the unreliability of the last due to the resistance between the earthed main and earth being of uncertain value. They suggest that the earthed-main should be earthed through a set of resistances of certain definite values ; the cutting-out devices to be operated by the current in these earth-circuits when the potential difference between the earthed-main and earth exceeds a certain predetermined limit. E. D. P.

318. *Aluminium Transmission Line.* **F. A. C. Perrine.** (Journal of Electricity, S.F. 8. pp. 41–42, August, 1899. Paper read before the Pacific Coast Electric Transmission Association, San Francisco, June 20–21, 1899.)—Tests of the 48-mile two-phase four-wire power transmission line of aluminium employed by the Standard Electric Company of California are given. The following are the main details. Power transmitted 1,000 kilowatts at 25,000 volts ; diameter of each wire 294 mils. ; weight 420 lbs. per mile ; tensile strength 1,539 lbs. ; resistance 2·11 ohms per mile ; insulation resistance 160,000 ohms to 44 megohms ; capacity 3·35 microfarads ; and self-induction

0·17 henrys per line. The variation of capacity, as well as of insulation, with the state of the atmosphere is noticed. L. B.

319. *Starting Resistances for Induction Motors.* F. Niethammer. (Elektrotechn. Ztschr. 20. pp. 604–605, August 24, 1899.)—The induced winding of an induction motor is generally provided with a starting resistance which, in the case of a three-phase winding, is connected star fashion to the winding. Such an arrangement is fairly complicated, and involves a large number of contacts. The author describes a number of starting resistances which are much simpler than those hitherto generally in vogue. In fig. 1 is shown an

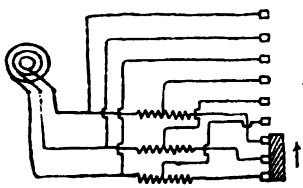


FIG. 1.

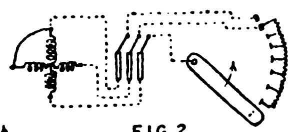


FIG. 2.

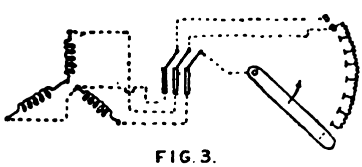


FIG. 3.

arrangement for a three-phase induced winding due to Kahlenberg, and used by Siemens and Halske. Fig. 2 may be used in connection with a two-phase winding, and fig. 3 shows another variety of a three-phase starting resistance. In the last case, there is a slight want of symmetry, since when the contact-arm has reached its extreme position, so as to bridge over the last two contacts, one phase is short circuited on itself, while the remaining two are joined in series and short circuited. A. H.

320. *Electric Transmission in Steel Works.* (Engineer, 88. pp. 45–46, July 14, 1899.)—This is a description of the electrical plant at the works of the Frodingham Iron and Steel Company, Doncaster. Electromotors are used to drive the line rolls and skids, through worm-gearing running in oil, with a speed reduction of 9·5 : 1. A furnace charging machine is also electrically driven. The motors are of 30 H.P. each, but are capable of working at 80 H.P. intermittently; they are of the enclosed type, with four poles and slotted armature cores. Each motor is governed by a controller, the starting, stopping, and reversing being effected with a single lever. Other motors are in use driving a crane and a slag-crushing mill. The plant is highly spoken of. A. H. A.

321. *Size of Motors for Driving in Workshops.* (Amer. Instit. Elect. Engin., Trans. 16. pp. 168–199, 1899.)—This topical discussion dealt with the question of subdivision of the motor equipment of electrically driven works, from the points of view of capital outlay, economy of power, and convenience. G. S. Dunn submitted data and curves showing that the direct saving of pow

effected by substituting three small motors for one large motor of equivalent power was trifling, but the indirect saving due to the idle periods of machines ranges from 15 to 50 per cent. The cost of three motors compared with that of one is 70 per cent. greater when the total power is 2 H.P., 28 per cent. greater for 50 H.P., and 2 per cent. less for 100 H.P. In at least one-half of the cases met with the question of convenience is paramount, and the gain in this respect far outweighs considerations of cost or economy. As the energy expended costs only from 0·5 to 1·8 per cent. of the value of a finished product, economy of energy is in any case unimportant. The absence of belts confers great benefits on workshops; the output of the Government Printing Office in Washington, the running expenses of which are £2,200 a day, was increased 15 per cent. by the adoption of direct-coupled motors throughout. Preference is given to small motors down to a limit of 5 H.P. for light, and 10 H.P. for heavy, machines. **R. T. E. Lozier** confirmed these statements, and gave practical details of the results of experience with a separate motor for each tool, showing amongst other things that the cost of repairs is small. No general rule can be laid down as to the use of direct-coupled *v.* geared motors. **H. W. Leonard** advocated the use of a four-wire distribution system, giving six different pressures for efficient speed regulation, and described a three-wire system with + or — booster, as well as a motor-dynamo system of delicate control at low speeds. **G. Hall** pointed out that very small ($\frac{1}{10}$ H.P.) motors fall in speed as their temperature rises, and are therefore not always satisfactory. In a certain case, where 14,000 books were manufactured per day, at a fuel cost (for power only) of £9, the adoption of motors increased the output to 22,000 books per day, while an outlay for fuel of £1 14s. per day covered the cost of power, lighting, and operating the elevators in a twelve-storey building. Instances were given of the saving in power due to the abolition of belting, and extreme subdivision of the motors was advocated. **H. B. Coho** described a case where it was preferred to drive 100 sewing machines with separate motors, at heavy cost, in order to avoid liability to break down. **O. Smith** recommended a separate motor to each machine down to a limit of 2 H.P., and gave details of his experience, stating that a 3 H.P. motor could easily work up to 15 H.P. momentarily. **G. S. Dunn** pointed out that H. W. Leonard's system did not apply to cases where constant power with varying torque and speed was required; for this, mechanical gearing was necessary. **A. Williams** emphasised the necessity of co-operation between the makers of motors and of the machines to be driven, and put the lower limit of subdivision at $\frac{1}{4}$ H.P. **J. M. Smith** said that in scarcely any factory are one-third of the machines in operation at one time; the great economy of electrical transmission is due to the stoppage of the motors when the machines are idle. **A. Williams** added a number of data of shaft losses varying from 18 to 68 per cent., and **G. Hill** stated that in numerous tests he had never found less than 50 per cent. loss. A. H. A.

322. *Electric Power in Engineering Works.* **L. Bell.** (Eng. Mag. 18. pp. 69–82, October, 1899.)—Three principles of economy underlie the efficient operation of any machine tool—

1. Keep it working steadily at or near its rated capacity.
2. Keep down friction, backlash, and lost motion of every kind.
3. Keep down manual labour.

To maintain a good load factor, the plant should have no periods of inactivity and no parts running idle. Economy is gained by using a separate

motor for each operative unit (for example, a group of a dozen automatic screw machines) and not a motor for each individual machine. Portable tools are recommended, equipped with their own motors, thus minimising transportation of work to and fro to the different shops. Enclosed arcs are advocated, naked arcs being too glaring and casting sharp shadows. M. O'G.

323. *Electrical Machinery in the United States Navy.* **A. D. Adams.** (Engineer, 88. pp. 233–234, September, 1899.)—The author points out various errors in the arguments which have been put forward, both for and against the use of electrical transmission of power to auxiliary machinery, and making liberal assumptions finds that electrical methods would save 67 per cent. of the steam at present consumed, or 80 lbs. steam per B.H.P. hour at the motors. The saving in weight of boilers and feed water due to this fact is generally overlooked; taking this into account, in a case where machines of 2,400 H.P. are installed, of which half are in use at one time, the total weight of steam equipment is 876,000 lbs., of electrical equipment 612,900 lbs., showing a gain of 263,100 lbs. with ordinary apparatus. When specially designed machinery of lighter construction is employed, such as is already on the market, giving 1 E.H.P. per 75 lbs. weight of engine and dynamo, the saving in weight is increased to 498,000 lbs., or more than 50 per cent. Further, it is shown that the extra cost of electrical equipment would be paid for out of the coal saved in less than seven months. Full details are given of the assumptions made in obtaining these figures. The electrical plant on board the *Iowa* is briefly described, and a number of arguments adduced regarding the advantages of electric cables as compared with steam pipes, &c. A. H. A.

324. *Electricity in Marine Work.* **S. D. Greene.** (Cassier, 16. pp. 207–222, July, 1899.)—This article deals generally with various applications of electricity to shipyard service and the minor functions on board ship, with many illustrations. (See also 1899, Abstract No. 759.) A. H. A.

325. *A 250 H.P. Electric Heating Plant.* (Elect. World and Engineer, 34. pp. 337–339, September 2, 1899.)—This paper describes the application of electric heating in a large hat manufactory in New Jersey, the heat being applied to irons, moulds, &c., for shaping and finishing felt hats. Although the cost of a heat unit generated electrically is necessarily greater than if generated by other means, the waste in the application of electric heat is a minimum, while in localisation, ease of control and cleanliness, it is superior to any other method; these advantages have made the installation under consideration a great success, and point to further applications of electric heating in other industries. M. G. W.

326. *Electrical Dredges.* (Elect. World and Engineer, 34. pp. 517–521, October 7, 1899.)—This is a well-illustrated description of a dredger built for the river Volga, which is electrically propelled and controlled. A 600 kw. three-phase generator is driven by a triple expansion engine, and supplies power to two motors in the stern and two in the bow, each of 125 H.P., and driving a 4-foot screw propeller, as well as to two 30 H.P. motors controlling the pontoon line. The motors are all of the induction type, and are controlled from the pilot-house. The dredge is capable of removing 7,000 cubic yards per hour. A. H. A.

327. *British Overhead Electric Travelling Cranes.* **A. G. Parrott.** (Cassier, 17. pp. 14–20, November, 1899.)—In mechanically driven travelling-

cranes a large proportion of the power applied is absorbed in merely moving the rope or revolving the shaft, and this consumption of power is constant whether the crane is working or not. Even in the busiest shops cranes are seldom engaged more than 40 per cent. of the working hours, the remaining time being occupied in preparing loads and adjusting slings. The electrically driven crane is superior in this respect to the mechanically driven one, and also in the facility with which the transmission of power can be made. The various advantages of electric cranes are discussed in simple language, and the practice of makers with regard to motors, switches, speeds, &c., are detailed. With the introduction of the high speeds of crane-travel it has been found necessary to increase the strength of the girders; the top flange should be designed so as to easily resist lateral strains which occur by suddenly stopping and starting the crane when fully loaded. A. S.

328. *Electric Canal Haulage.* **G. Klingenberg.** (Elektrotechn. Ztschr. 20. pp. 541–546, August 3, 1899.)—A description of a series of experiments made by Siemens and Halske in electric haulage on the Finow Canal. Two systems were tried—that of Lamb, and a new one designed by Köttgen. One kilometre of canal was equipped with the necessary overhead lines, continuous current at 500 volts being employed in each case. In the Lamb system a 5 H.P. series motor is carried in a truck weighing one ton in all and runs on an overhead cable. Owing to the strains set up it was found impossible to support this cable on insulators, and a second line had to be erected to supply the current.

The barges are towed by ropes as usual. Owing to the suspension of the motor, the construction of curves offers great mechanical difficulty. The supporting wire is subjected to severe bending strains, and an accident of any kind causes a serious interruption in the traffic owing to the great weight of the suspended motor. The compensating advantage lies in the fact that the tow-line is carried well overhead.

In the Köttgen system a small electric locomotive is employed of some two tons weight. The wheels on one side only are driven, these carrying 85 per cent. of the weight of the locomotive, thus giving stability against the side strain of the tow-line. The other wheels run either on a light rail or on the paved tow-path.

A rack system was tried but abandoned in favour of simple adhesion. The normal speed is three miles per hour when exerting a tractive force of 12 cwt. A series motor is used, and hence a much higher speed is attained when the loco. is running light. Details of the experiments and a summary of the advantages of electric haulage are given. L. B.

REFERENCES.

329. *Progress of Primary Batteries in the last Twenty-five Years.* (Elektrochem. Ztschr. 6 pp. 148–153, October, 1899.)

330. *Description with Particulars of Sizes and Results of Tests on Pescetto Accumulators.* **J. Reyval.** (Écl. Électr. 21. pp. 137–138, October 28, 1899.) (See Abstracts, 1898, No. 431, and 1899, No. 1245.)

331. *Aron Energy Meter.* **M. Aliamet.** (Électricien, 17. pp. 337–339, June 3, and pp. 354–360, June 10, 1899.)—This is a description of the latest form of the Aron meter.

GENERATORS, MOTORS, AND TRANSFORMERS.

332. *Low-voltage Dynamos.* **E. K. Scott.** (Electrician, 43. pp. 904–905, October 20, 1899.)—The author discusses the design of dynamos for electro-chemical work with special regard to the difficulty of collection, and points out the advantages of the internal field type with ring armature, the conductors on the external periphery of which are used as commutator bars. The large brush surface obtained permits of the use of cheap carbon brushes—an important point; in one case where the renewal of copper brushes cost £30 to £40 per month, the substitution of carbon reduced the outlay to a nominal figure. The saving in cost of construction of the internal-field machine is also referred to.

For smooth-core armatures which are liable to short circuits, the Oerlikon Company uses brass discs at intervals in the core, which are perforated to carry the conductors and hold them in place. A. H. A.

333. *Brush Multicircuit Arc Dynamo.* (Amer. Electn. 11. pp. 436–437, September, 1899.)—Three circuits of 42 lamps each are run off a 125 light Brush arc-light dynamo. Each circuit is connected between the positive brush of one armature section and the negative brush of the next, so that, although the three circuits are really in series, there are only 2,100 volts in each. The current is controlled by a new form of oil regulator, which consists of an oil pump driven off the shaft by a belt supplying oil through a two-way valve to a rotary piston which works the rheostat arm and brush-rocking mechanism. The valve is worked by a solenoid in the main circuit, with an excess current it admits oil to one side of the piston, and with a current less than normal, to the other side. The valve and ports are made so that in the normal position the oil leaks past both ports. R. B. R.

334. *Arc-Machine Regulation.* **H. F. Watts.** (Elect. World and Engineer, 34. pp. 157–158, July 29, 1899.)—The author advocates the use of the Thomson-Houston regulator on modern arc-lighting dynamos.
W. G. R.

335. *Armature Reaction in Dynamos.* **R. V. Picou.** (Soc. Int. Élect., Bull. 16. pp. 160–173, 1899.)—Instead of attributing the fall of potential between the brushes of a dynamo as the load increases to a demagnetising effect of the armature currents (in addition, of course, to a fall of potential due to the resistance of the armature itself), the author prefers to attribute it to an increase in the reluctance of the magnetic circuit. Whichever explanation is given the fall of potential is due to a diminution of the useful flux through the armature. The change in the reluctance is due to the deformation which the magnetic field undergoes on account of the effect of the armature current, and is constant so long as the lead of the brushes is less than half the interpolar angle; whence the fall of potential is independent of the lead of the brushes and cannot therefore be due to the opposing ampere turns of the armature. The author supports his theory by proving experimentally that the fall of potential between the brushes is independent of their lead and then showing by calculation that the effect of the increase of the reluctance due to the deformation of the magnetic field agrees with the

experimental results. The effect of the armature current is to modify the distribution of the magnetic flux. These modifications are as follows: (1) In the magnets the lines of force undergo a slight increase of length. In the yoke and limbs there is no change of induction in any way whatever; but in the pole-pieces in the neighbourhood of the air-gap the induction varies from point to point and consequently the permeability also. (2) In the air gap the magnetic path is lengthened. (3) In the armature there is little or no change of permeability, but the mean length of the magnetic path is increased.

W. G. R.

336. *Armature Reaction in Alternators.* **A. Blondel.** (Comptes Rendus, 129. pp. 586-589, October 16, 1899.)—Considering the case of a polyphase alternator symmetrically loaded, the author points out that the actual armature reaction corresponding to a given phase displacement may be regarded as made up of (1) an opposing magnetic flux due to the idle component of the current; (2) a cross-flux due to the load component. So long as the magnetisation is well below saturation, the effect of armature reaction may be expressed in terms of two coefficients of self-induction, l (corresponding to load current) and l^1 (corresponding to idle current), by the vectorial equation

$$\overline{E_a}=\overline{rI}+\overline{lpI\cos\psi}+\overline{l'pI\sin\psi},$$

where E_a is the drop of potential due to armature resistance and reactance, r the resistance of the armature, and ψ the phase-difference between the E.M.F. and current. The vectors $\overline{lpI\cos\psi}$ and $\overline{l'pI\sin\psi}$ are in quadrature with the currents $I\cos\psi$ and $I\sin\psi$ respectively, while $\overline{rI}$ is in phase with I. In cases where the permeability can no longer be regarded as constant, we must, instead of considering l', determine the magnetomotive-force corresponding to it, and compound this with the magnetomotive-force due to the field winding.

A. H.

337. *Armature Reaction in Alternators.* **A. Potier.** (Comptes Rendus, 129. pp. 637-640, October 23, 1899.)—Referring to Blondel's paper (see preceding Abstract), the author states that the assumption by that writer of two different coefficients of self-induction for the armature is intended to emphasise the fact that the inductance of the armature varies according to its position in the field, and is a periodic function of frequency double that of the E.M.F. Taking the general differential equation of current—

$$Ri+\frac{d}{dt}(Li)=E\sin pt,$$

the author considers the special case in which $L=\frac{L_1}{1-2\alpha\cos 2pt}$, and obtains a solution in the form of a convergent series arranged according to power, of α. If, therefore, the E.M.F. follows the simple harmonic law, and L is variable, the current can no longer be assumed to be a simple harmonic one—an assumption implied in Blondel's treatment of the subject. The author further obtains a solution of the differential equation of current when the E.M.F. is expressed by a Fourier series, and $L=L_1/(1-2\alpha\cos 2pt-2\beta\cos 4pt-2\gamma\cos 6pt-\ldots)$

A. H.

338. *Sparkless Running of Dynamos.* **H. Isler.** (Elektrotechn. Ztschr. 2 pp. 714-716, October 12, and 732-734, October 19, 1899.)—In this elabora paper the author seeks to establish criteria whereby the behaviour of a machi

all of whose constructional details are accurately known may be estimated as regards sparking. The differential equations of the current in the short-circuited coil, and the currents passing to or from the commutator segments, are first developed. From these equations the author deduces a relation connecting the mean induced E.M.F. during the period of short circuit with the armature current, the inductance of the coil, and the time of the short circuit —on the suppositions that the current-density under the brush remains uniform, and that the induced E.M.F. obeys the straight-line law. By means of this relation, and from the known intensity in the air-gap, it is possible to predetermine approximately the lead of the brushes. The calculation of the brush contact resistance and the inductance of the coil in various cases is next considered. The author points out that a machine having a very small brush lead is not necessarily a satisfactory one, since sparkless commutation may be only possible within very narrow limits, and the brushes may require careful adjustment. He then proceeds to develop some other formulæ, which furnish further tests as to the non-sparking quality of a machine. A long table, containing various data of a number of actually constructed machines, is appended to the paper. A. H.

339. *Paralleling of Gas-driven Alternators.* **G. Dettmar.** (Elektrotechn. Ztschr. 20. pp. 728–730, October 19, 1899. Read before the 7 Jahresversammlung des Verbandes Deutscher Elektrotechniker at Hanover.)—The principle of the device patented by the author has already been briefly explained in Abstract No. 1273 (1899). The magnetic brake consists of a powerful electromagnet whose pole-pieces are placed in close proximity to the rim of the engine fly-wheel. The braking effect is due partly to hysteresis and partly to the powerful eddy-currents induced in the rim. The magnet coil is connected in series with a regulating resistance which enables the load to be varied. Such an electromagnetic brake costs less than an artificial load of wire resistances. It is in use at some lighting stations in Germany, and the author cites a case in which two gas-driven alternators are paralleled without any noticeable disturbance by means of such a brake, whereas any attempt to parallel them without it gives rise to very heavy equalising currents and consequent fluctuations in the P.D. of the mains. A. H.

340. *Hunting of Paralleled Alternators.* **P. Boucherot.** (Écl. Électr. 21 pp. 121–127, October 28, 1899.)—Referring to Kapp's article on this subject (see 1899, Abstract No. 1085), the author points out that as far back as 1892 he had, in *La Lumière Électrique*, vol. xlv., given an explanation of the see-sawing action which is sometimes observed to take place between paralleled machines. A portion of the original article is reproduced, and the author then gives the following approximate formula for the period of oscillation T of the alternator rotor:

$$T = 2\pi n\sqrt{\frac{20\pi M}{f E I}}$$

in which n stands for the revolutions per second, M for the moment of inertia of the rotor (kilogramme and metre as units), f for the frequency, E for the bus bar P.D., and I for the short-circuit current of the alternator corresponding to normal excitation. This formula agrees with that given by Kapp.[1] In

[1] The formula as originally given in Abstract No. 1085, 1899, is wrong on account of a typographical error in Kapp's paper; the correct expression is—

$$2\pi\sqrt{\frac{vdm}{0{\cdot}102\pi ei}}$$

dealing with two-phasers, 2EI, and in dealing with three-phasers, $\sqrt{3}$EI must be substituted for EI in the above formula. In the case of a three-phaser, E stands for the P.D. between any 2 terminals, and I for the short-circuit current flowing towards or from each terminal. The author points out that T is not quite constant, but decreases with the load, and this decrease may, in alternators with powerful armature reaction, amount to as much as 20 or even 25 per cent. In order to avoid see-sawing the author recommends making T as large as possible in comparison with the periodic time of the impulses of the prime mover (avoiding ratios of 1, 3, 5, &c.), preferably by making M large. A. H.

341. *Hunting of Paralleled Alternators.* **A. Blondel.** (Écl. Électr. 21. pp. 215-216, November 11, 1899.)—The author states that almost simultaneously with Boucherot (see preceding Abstract), he had, in *La Lumière Electrique*, vol. xlvi., given a solution of the problem of the see-sawing of paralleled alternators. The formula obtained by him is

$$T=\frac{2\pi}{P}\sqrt{\frac{9{\cdot}81Mp}{E\cos\theta(I\sin\phi-I_e\sin\psi)}}$$

where T is the period of the oscillation; P=number of like poles on one side of armature; M=moment of inertia of rotor (kilogramme and metre as units); $p=2\pi\times$frequency; E=E.M.F.; θ=angle of oscillation; I=short-circuit current corresponding to normal excitation; I_e=actual current; $\tan\phi=\frac{pl}{r}$; $\tan\psi=p\frac{2L+l}{2R+r}$, where r, R stand for the resistances, and l, L for the inductances, of the alternator armature and the external circuit respectively. If instead of two machines there are m of them, then $\tan\psi=p\frac{mL+l}{mR+r}$. This formula is more general than those given by Boucherot and Kapp, and includes the latter as special cases ($\cos\theta=1$; $\sin\psi=0$). The author points out that since I_e increases with the load, the value of T would, at constant excitation, *increase with the load.* It is only on account of the fact that with increasing load the excitation (and therefore E) has to be increased in order to maintain a constant P.D., that T decreases with the load—the effect of increased excitation more than counter-balancing the effect due to the increase in I_e. A. H.

342. *Vector Diagram of Paralleled Alternators.* **C. F. Guilbert.** (Écl. Électr. 20. pp. 321-328, September 2, 1899.)—The author considers the graphical treatment of the following problem: two alternators being coupled in parallel, and the P.D. across their terminals being maintained constant, to find the law connecting the E.M.Fs, currents and powers of the two machines when any one of these quantities is made to vary. A number of vector diagrams illustrating various particular cases accompany the paper. A. H.

343. *Divided Closed-Coil Windings.* **G. Ossanna.** (Zeitschr. Elektrotech. Wien. 17. pp. 347-353, June 25, 1899.)—The author considers how an ordinary closed-coil winding of the Gramme or drum type may, by opening it at a number of points and then suitably connecting the different groups of conductors, be adapted to various special purposes. Let an armature with a given number of uniformly distributed external conductors be supposed *to revolve* in a two-pole magnetic field having a sine distribution round the *armature periphery.* Each conductor then becomes the seat of an alternating

E.M.F. obeying the sine law, but at any given instant the phases of the various E.M.Fs. are different. These E.M.Fs. may be represented in a vector diagram by drawing a circle and inscribing in it a regular polygon of as many sides as there are conductors. The projections of the sides of the polygon (which is supposed to revolve synchronously with the armature) on a fixed straight line will then give the instantaneous values of the various E.M.Fs. The resultant E.M.F. due to any group of conductors, such as that included between points I and I′ (fig. 1), is represented in magnitude and phase by the corresponding chord II′. The following groups of windings are considered by the author: (A) Windings by means of which three-phase currents may be obtained of an E.M.F. other than that which alone would be possible if the winding remained closed. Examples are shown in figs. 2 and 3. In both cases the closed winding is cut open at three points 120° apart (I, II and III in fig. 1). In fig. 2 the ends I′, II′ and III′ are joined together, and the ends I, II and III are connected to slip-rings from which three-phase currents may be obtained. This gives, in fact, an ordinary "star" winding.

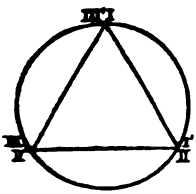


FIG. 1.

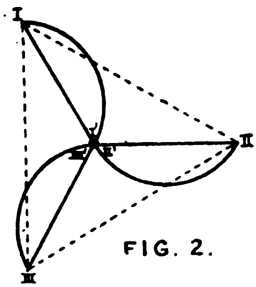


FIG. 2.

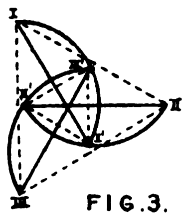


FIG. 3.

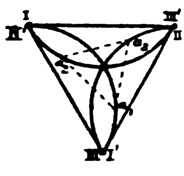


FIG. 4.

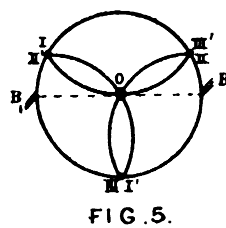


FIG. 5.

The E.M.F. between any two mains is here $\sqrt{3}$ times that which would have resulted if the winding had remained closed. Fig. 3 shows an arrangement whereby the same armature may be made to supply two distinct three-phase circuits, viz., a high-voltage motor circuit connected to I, II, III, and a low-voltage lamp circuit connected to I′, II′, III′. (B) Windings by means of which a high starting torque may be obtained in the rotors of induction motors *without the use of starting resistances*; this higher torque is obtained by reducing the E.M.F. in the induced winding at the moment of starting, so as to necessitate a much greater slip than the normal one for the production of a given current. An example is shown in fig. 4, in which a_1, a_2, a_3 are three symmetrically placed points in the three arcs of the winding; these three points are at starting connected together, and the slip required to produce a given torque is then $\left(\frac{\text{I II}}{a_1\, a_2}\right)^2$ times greater than that corresponding to a connection of I, II, III; this last connection is established when the motor has run up to speed, and after the points a_1, a_2, a_3 have been disconnected. (C) This group of windings applies to *cases in which the* armature is provided

with two independent windings, one of which is connected to a commutator in the usual way. An example is shown in fig. 5, in which B_1, B_2 are the brushes of the closed-coil winding, whilst the points I, II, III of the divided winding are connected to points of the same potential in the closed-coil winding. The point O at which the six sections of the divided winding meet possesses the property that it always halves the E.M.F. between the brushes. Hence by connecting O to the balancing wire of a three-wire system, the machine may be used either as an equaliser or as a three-wire generator, and the cross-section of the conductors in the divided winding need only be large enough to enable them to carry the equalising current. Besides the examples shown in figs. 2–5, the paper contains a very large number of diagrams showing various other arrangements of a divided closed-coil winding. A. H.

344. *Resistance of Dynamo Brushes.* (Elect. World and Engineer, 34. pp. 417–419, September 16, 1899.)—A series of experiments made by R. B. Tibbals, L. Lowenberg, and W. G. Burns on a 35 kw. dynamo is described. With other results it was found that—the resistance of all kinds of brushes varied inversely as the current; the friction of carbon brushes varied in a similar manner; brushes of Babbitt metal, when oiled, ran better than any other kind experimented with; the friction of the latter increased with increasing current.

With a 200 kw. eight-pole dynamo, having a commutator 32 inches diameter, 268 bars, 64 brushes in eight sets, the friction diminished with increase of current, oil being used; the resistance of graphite brushes was increased, that of copper-gauze brushes diminished, by the use of oil. With large commutators the application of oil increased the friction, but with a small commutator the contrary took place. Many other conclusions, of minor importance, are given in the paper, and a large number of experimental curves. A. H. A.

345. *Weston Winding for Three-wire Dynamos.* **A. Sengel.** (Elektrotechn. Ztschr. 20. pp. 525–527, July 27, and 548–550, August 3, 1899.)—By placing a third brush half-way between the main brushes of a dynamo, two circuits, each at a P.D. equal to half the terminal P.D. of the machine, may be supplied. Such an arrangement may be used in connection with a three-wire distributing system. The difficulty due to sparking at the intermediate brush may be overcome in various ways. The author points out that armatures provided with a Weston winding—*i.e.*, one consisting of two (or more) independent closed windings, the commutator segments of the one winding being sandwiched in between those of the other—are especially suitable for this purpose. The main brushes of the machine must in this case cover as many commutator segments as there are windings. By making the third brush only wide enough to cover a single segment, short-circuiting of single coils by this brush is prevented. When running on open circuit a certain amount of sparking at the intermediate brush still takes place, on account of the differential action between the two branches of the winding which connect each main brush with the intermediate one. The author made the singular discovery that the amount of sparking is dependent on the polarity of the pole-piece under which the intermediate brush is placed, a good deal more sparking taking place when the current passes from the brush to the receding commutator segment than when the reverse arrangement is adopted. When the machine is loaded on one side only its behaviour with regard to sparking depends on whether the load circuit

between the intermediate brush and the main brush in advance of it, or the intermediate brush and the main brush behind it. In the former case the sparking decreases with increase of load up to a certain limit at which it practically vanishes and beyond which it reappears. In the second case, the sparking steadily increases with the load. These effects may be explained by considering the armature reaction and current distribution in each case. The author concludes from his experiments that when carbon brushes are used, machines constructed on the above plan are capable of giving good results when used on a three-wire network on which the want of balance does not exceed 20 per cent A. H.

346. *Wagner Single-Phase Motors.* (Amer. Electn. 11. p. 299, June, 1899.)—A description of tests of a 5 H.P. Wagner Electromotor carried out by R. B. Owens, University of Nebraska. The construction of the motor is not described, but it consists of a motor started by placing the armature with commutator and brushes, in series with a field excited by the inducing coil, thus forming a series motor. When run up to speed the armature coils are short circuited, and the motor runs as an induction motor. No results are given of the current, torque, or power factor at starting. When running, the motor gives a maximum efficiency of 78 per cent. and a power factor of 88 per cent. Curves are given showing the variation of these with variations of terminal pressure. The frequency of supply is not stated. The efficiency of the motor when hot was 2 to 3 per cent. higher than when cold, stated to be due to a reduction of iron losses. Ll. B. A.

347. *Induction Motors.* **C. A. Carus-Wilson.** (Elect. Rev. 45. pp. 697–698, October 27, 1899. Lecture delivered before the Royal Institution, April 28, 1899.)—The theory of the alternating current motor was illustrated in an interesting way by aid of the oscillograph, the author showing that the law of force variation, with synchronously varying field and current, was such that two series of impulses at right angles gave a uniform impulse when acting together. It was thus possible to construct an alternating current motor in which the sum of the turning moments on the shaft was a constant quantity; the well-known induction motor giving such a result.

The rotating magnetic field of the induction motors was illustrated by an experiment in which a small permanent magnet carrying a mirror was centred upon a vibrating rod placed between two pairs of electro-magnets. When two opposite magnets were excited the mirror vibrated between them and reflected a spot of light on to the screen, tracing out a vertical line. When the second pair of opposite magnets was excited the spot traced out a horizontal line of equal amplitude. Both sets were then excited together by currents in step with each other, with the result that the spot vibrated in a line, making an angle 45° with the former lines of vibration. When, however, the exciting currents were made to differ by one-quarter of a period the spot of light reflected from the mirror described a circle, showing that the magnetic field produced by two magnets set at right angles, and excited by two currents differing by a quarter of a period, is of uniform intensity and rotates at a uniform rate. E. K. S.

348. *Heyland Single-Phase Motors.* **A. C. Eborall.** (Elect. Rev. 45. pp. 510–513, Sept. 29, 1899.)—The Heyland motors differ but little with regard to general design from other well-designed motors of the induction type. It is in the method of the stator windings that *novelty is claimed* for them. The

starting coil has few turns, while the running coil is divided into sections which are successively cut in as the speed of the rotor increases, one section only being used at the instant of start.

The rotor is wound in the tri-phase star fashion, the free ends being connected to three collector rings rigidly attached to the rotor shaft, but electrically insulated from it and from each other.

The accompanying table gives particulars of these motors in sizes varying from $\frac{1}{10}$ to 100 H.P. for 50 cycles and 100 to 800 volts.

B.H.P.	Revs. per minute.	Power factor. Per cent.	Efficiency Per cent.	Weight. Lbs.	B.H.P.	Revs. per minute.	Power factor. Per cent.	Efficiency Per cent.	Weight Lbs.
$\frac{1}{10}$	1,500	55	50	66	20	1,000	82	85	1,100
$\frac{1}{2}$	1,500	65	65	148	40	750	85	89	2,640
1	1,500	70	70	154	60	750	85	90	3,500
5	1,500	75	80	440	80	750	85	90	4,400
10	1,000	80	82	660	100	750	85	91	5,000

The motors are designed on the following lines :—

1. Temperature-rise after eight hours at full load will not exceed 40° C.
2. Drop of speed varies from 10 per cent. in the smallest sizes to 3 per cent. in the largest motor.
3. All motors have a loading limit of 1½ times the full load.
4. The motors are designed either to start up with a torque equal to full load, the current consumption being twice the full load current, or else to start with a torque equal to two-thirds of that at full load, the current being 1½ times the full load current.

W. G. R.

349. *Frictional Losses in Induction Motors.* **R. Braun.** (Elektrotechn. Ztschr. 20. pp. 685–687, September 28, 1899.)—The following methods may be used for determining friction losses in induction motors: (1) The simplest is to measure the power absorbed by the motor when running light, then suddenly to open-circuit the induced winding and take another wattmeter reading as quickly as possible. The difference of the two readings is practically equal to the frictional loss. (2) The second method consists in finding the retardation curve of the rotor, and from the moment of inertia of the rotor and its retardation finding the required frictional loss. (3) A small auxiliary motor whose efficiency is known may be used to drive the rotor. (4) Very reliable results may be obtained by measuring the brake-power w (in watts) at the motor pulley, the percentage slip s corresponding to this, and the slip s_0 when running light. If w_0 stand for the required frictional loss in watts, then the author shows that—

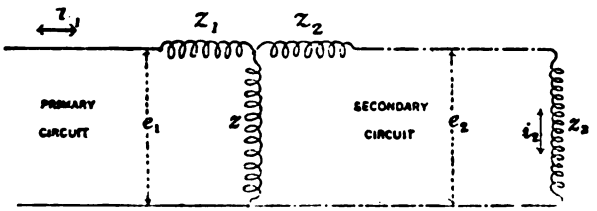
$$w_0 = \frac{w}{\frac{N^2}{N_0^2} \cdot \frac{s_0(100-s)}{s(100-s_0)} - 1}$$

where N and N_0 stand for the total magnetic flux through a rotor winding when loaded and running light respectively. The author finds that the mean value of N^2/N_0^2 for well-designed motors is 0·9. A number of actual tests are described illustrating the use of this method, which is very convenient as a check on results obtained by method (1).

A. H.

350. *Predetermination of Drop in Transformers.* **A. E. Kennelly** (*Elect. World and Engineer*, 34. pp. 343–344, September 2, 1899.)—Tran

former calculations are much simplified by supposing the secondary circuit replaced by an equivalent circuit giving a ratio of transformation equal to unity. If n is the actual ratio of transformation (or ratio of secondary to primary turns), then in effecting the reduction mentioned all secondary P.Ds. must be divided by n, all secondary currents multiplied by n, and all secondary resistances, reactances or impedances divided by n^2. We may next suppose the primary and secondary circuits conductively connected as in the fig., where z_1=impedance corresponding to primary leakage flux, z=im-



pedance corresponding to flux common to the two coils, z_2=impedance corresponding to secondary leakage flux, z_3=impedance of secondary load, each impedance being expressed as a complex quantity ($=r+ix$, where $i_2=-1$). If e_1 stand for the primary and e_2 for the secondary P.D. respectively, then we have—

$$\frac{e_2}{e_1}=\frac{z_3}{z_1+z_2+z_3+z_1\left(\frac{z_2+z_3}{z}\right)} \qquad (1)$$

In most cases, z is so large in comparison with the other impedances, that the last term in the denominator of the right-hand fraction may be neglected, and we may write—

$$\frac{e_2}{e_1}=\frac{z_3}{z_1+z_2+z_3} \qquad (2)$$

In order to find e_2/e_1 for any given load, we must know z_1, z_2 and z_3. The latter is known from the nature of the load. To find z_1+z_2, we short circuit the 2ary coil through an ammeter, and measure the 1ary P.D., e_1, required to produce a current i_2 in the short-circuited secondary. Then $z_1+z_2=\frac{e_1}{i_2}$. Since the sum of the resistances r_1+r_2 is known, we easily find the sum of the reactances $i(x_1+x_2)$, so that z_1+z_2 is completely determined. Equation (2) then enables us to find the drop for any given load. A. H.

351. *Magnetic Leakage in Transformers.* **A. Russell.** (Electrician, 42. pp. 567–569, 603–604, 788–789, and 823–824, 1899.)—In this series of four articles the author develops formulæ for ascertaining the magnetic leakage in transformers with varying loads. The author points out the importance of including magnetic leakage in the calculation for the design of transformers, and also the influence of magnetic leakage on the efficiency of transformers. The common method of estimating this leakage by subtracting from the open circuit secondary voltage, the secondary voltage at full load and the copper drop is not satisfactory, owing to the small differences concerned. The author is of opinion that the measurement of angle of lag of the secondary current behind the E.M.F., caused by the driving flux in the core, is much more useful in determining the leakage. This angle varies with the shape of the E.M.F. waves, and is proportional to the current in the secondary coils,

The author proceeds to give a vector diagram of the various voltages in the primary and secondary circuits of a loaded transformer, and deduces from this the angle of lag due to the leakage above mentioned. He then develops from the diagram the expressions for the sine, cosine, and tangent of the angle of lag in terms of the angles of lag in the primary and secondary circuits and the currents in the same. One development of these formulæ is as follows:—

$$\cos a = \frac{W_1 - W_0}{nV_1A_2}$$

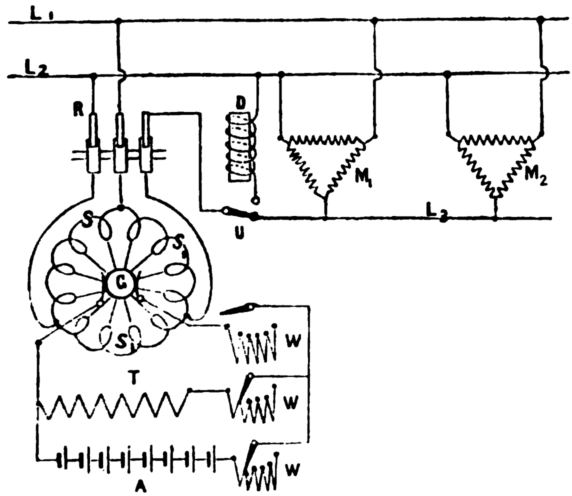
Where a = the angle of lag determining the leakage, W_1 = the watts given to the primary, W_0 = the watts taken by the transformer, on open circuit, n = the transforming ratio of the transformer multiplied by a constant, V_1 = the volts applied to the primary and A_2 = the secondary current. The author next develops expressions for determining the secondary voltage, and also the efficiency of a leaky transformer. The shape of the wave of the applied E.M.F. is important because it determines the maximum induction, and hence the hysteresis loss. Curves with a high centre of gravity generally produce less induction in the core than curves whose centre of gravity is lower. The author calls attention to other experimenters in this field, and particularly to Roessler's experiments. The figures obtained by this expert are then analysed by the author with the formulæ obtained earlier in the articles. Thus with one transformer supplied by a Ganz alternator with pointed curves the lag due to leakage was found to be 2·1 degrees per ampere of secondary current. With the same transformer supplied by a Wechsler alternator with rounded curves the angle of lag was only 1·1 degree per ampere of secondary current. The frequency in each case was the same. The author also analyses Fleming's test on a Swinburne hedgehog transformer, where the leakage was naturally very much greater. R. W. W.

352. *Transformer Economy.* **F. H. Leonard, Jr.** (Canad. Elect. News, 9. pp. 154–155, July, 1899.)—A good summary of known factors influencing the economy of transformers in practice. Reasons are given in favour of the shell type as against the core type. In regard to the ageing of transformer cores, it is stated that, three years since, one of the largest firms in the States had to take back every transformer supplied four months before to a large central station, owing to the rapid increase in core losses, which, in some cases, had actually doubled. The new cores supplied showed no apparent ageing after nine months. Apparently two lots of iron from the same manufacturers may exhibit differences of 10 or 20 per cent. in the core loss factor. Hence the importance of careful tests in factories. W. E. S.

353. *Motor Transformer for Charging Small Accumulators for Automobiles.* **A. Soulier.** (Ind. Élect. 8. pp. 392–394, September 10, 1899.)—A small continuous-current transformer for charging the cells of petrol-driven automobiles. It is a single-core machine weighing only 9·6 kg., with two windings, one receiving current at 110 volts and the other furnishing low-pressure current for three, four, or five cells. The secondary winding consists of only one bobbin, so that the current supplied is practically rectified current; this variable current has, however, been found to answer well enough in practice. E. K. S.

354. *Starting Device for Synchronous Phase-Transformer.* (Elekt. Runds. *16. p.* 221, July 1, 1899.)—The arrangement of connections (used by Schuckert

and Co.) is shown in the accompanying sketch, in which L_1, L_2 are the single-phase supply mains, and M_1, M_2 three-phase induction motors connected between L_1, L_2, and a supplementary main L_3, which receives current from the windings S_1 of the phase transformer. The latter may take the form of an ordinary rotary converter, and will run as a synchronous motor when supplied with single-phase current, developing the phase-displaced currents required by the motors. Two methods of starting the phase transformer may be used. The first consists in producing a phase-displacement between the currents in S and those in S_1 by means of a choking-coil D, so as to obtain a rotating field

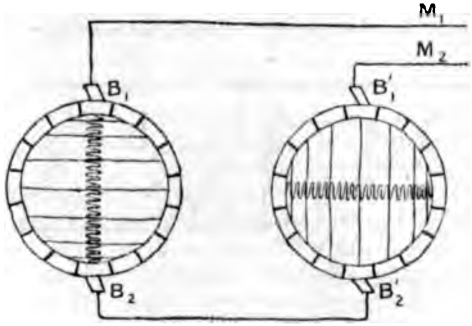


in the armature; the field coils T being short circuited the transformer will start. But since it could never be brought up to synchronous speed by this method, a device for temporarily halving the number of field-poles is provided; the transformer may then be run up to a speed above synchronism, the current switched off, the normal field connections restored, the current switched on at synchronism, and the field excited. In order to prevent sparking when the transformer is self-exciting, a steadying secondary battery is used. This latter, however, also provides another method of starting, by enabling the transformer to be run up to synchronous speed as a simple continuous-current motor. A. H.

355. *Study of Rotary Converter.* **K. Pichelmayer.** (Elektrotechn. Ztschr. **20.** pp. 697–701, October 5, 1899.)—The paper contains a number of interesting curves showing the E.M.F. and current waves under various conditions of working, and curves showing the field distribution. All the results given were obtained experimentally. A. H.

356. *Rectifiers.* **L. Kallir.** (Zeitschr. Elektrotechn., Wien. **17.** pp. 460–464, September 8, 1899.)—The author describes some modifications of the Hutin and Leblanc *panchahuteur* (see 1899, Abstract No. 505), which have certain advantages over the latter. In the accompanying figure, which is a purely diagrammatic representation of the arrangement, the wavy line represents the secondary winding of a stationary transformer. The winding is divided into sections, the number of turns in a section varying according to

the sine law. From the points of junction of consecutive sections connections are established, by means of slip-rings and brushes, with the segments of a commutator, after the manner shown in the sketch. The slip-rings and commutator are driven at the speed of synchronism by means of a synchronous motor. If the supply is a single-phase one, then only one commutator will be required. By means of two brushes, B_1 and B_2, placed in such a position that when the secondary E.M.F. is at its maximum the whole of the secondary turns are in circuit, a pulsating uni-directional current may be obtained in a circuit connected across the brushes. The pulsations may



be damped by means of a choking-coil. Such an arrangement has a twofold advantage over a *panchahuteur:* (1) the number of slip-rings is reduced to one-half, (2) the copper loss is reduced by about 88 per cent. If the supply is a two-phase one two commutators will be required, and by connecting these in series, as shown in the figure, an absolutely steady continuous P.D. will be obtained between the mains M_1 and M_2. Lastly, the same arrangement is applicable to a three-phase system, by using Scott's method of coupling the transformer windings so as to pass from three to two phases. (See **1899**, Abstract No. 1090.) A. H.

REFERENCES.

357. *Synchronising of Alternators.* **M. R. Gardner** and **R. P. Howgrave-Graham.** (Instit. Elect. Engin., Journ. 28. pp. 658–664, August, 1899.)—Abstract of paper read before the Students' Section.

358. *Starting and Regulation of Motors.* **C. F. Guilbert.** (Écl. Électr. **21.** pp. 46–54, October 14, 1899.)—Recent Patents (see 1899, Abstract No. 756).—(Pp. **207–215**, November 11, 1899) Illustrated description of various alternating current motors. (See 1899, Abstract No. 1577.)

359. *Brush Rocker Details and Bearings.* **E. K. Scott.** (Elect. Rev. **45.** pp. 665–667, October 27, 1899.)—Illustrated description of the design of various brush rocker bars and dynamo bearings.

360. *Standardising Carbon Brushes.* **E. K. Scott.** (Elect. Rev. 45. pp. 862–864, November 24, 1899.)

361. *Design of Rotary Converters.* **H. F. Parshall** and **H. M. Hobart.** (Engineering. 68. pp. 389–391, September 29th, and p. 450, October 13th) Single-Phase Rotary Converters.—(Pp. 517–519, October 27th) Six-Phase Rotary Converters.—(Pp. 620–621, November 17th, 1899) Four-Phase Rotary Converters,

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

362. *Current Distribution in Alternate-Current Networks.* **C. P. Feldmann and J. Herzog.** (Elektrotechn. Ztschr. 20. pp. 780–788, November 9, 1899; read before the 7 Jahresversammlung des Verbandes Deutscher Elektrotechniker in Hanover.)—The principles and methods governing the calculation of current distribution in continuous-current networks are well known. In the present paper the author extends such methods to the case of alternating currents, by the very simple and elegant device of supposing the currents which are drawn off at the various points of the network split up into their idle and load components. Two diagrams are then drawn for the network, in one of which are shown the idle currents, and in the other the load currents. The problem is next solved separately for each of these two cases, the idle and load current distributions being determined by the ordinary methods used in connection with continuous-current networks. Finally, the two solutions are superposed (the superposition of currents being, of course, a *vectorial* one), thus giving the required solution of the problem. A numerical example is worked out by way of illustration. A. H.

363. *Calculation of Sizes of Distributing Mains.* **A. Hecker.** (Deutsche Zeitschr. Elektrotechn. 6. pp. 162–165, October 15, and 173–176, November 1, 1899.)—The author considers the case of a distributor, simple or branched (and fed from one end only), the total fall of potential along which is given. He then supposes that the cross-sections of the various sections of the distributor are varied until the total amount of copper required for the distributor becomes a minimum, and deduces formulæ for the drop of potential along each section of the distributor when the conditions of (1) given total drop and (2) minimum total copper are satisfied. A. H.

364. *Insulation Difficulties due to Capacity of Alternate Current Networks.* **M. Leblanc.** (Écl. Électr. 21. pp. 81–94, October 21, and 172–180, November 4, 1899.)—A long paper, mainly of a mathematical character, in which the difficulties of properly insulating networks liable to disturbances due to resonance effects are fully discussed. The author is opposed to the use of concentric cables as being particularly dangerous in this respect. A. H.

365. *Current Chart for Two and Three-Phase Lines.* (Amer. Electn. 11. pp. 392–393, August, 1899.)—Two charts, constructed by S. Q. Hayes, are given, based on the following formulæ:—

1. $\text{Volts} \times \text{Amps.} \times 2 \times \text{P.F.} = \text{K. W.} \times 1{,}000.$
2. $\dfrac{\text{K. W.}}{\text{Volts} \times 2 \times \text{P.F.}} = \text{Amps. per Phase} \div 1{,}000$ (two-phase).
3. $\dfrac{\text{K. W.}}{\text{Volts} \times \sqrt{3} \times \text{P.F.}} \times \text{Amps.} \div 1{,}000$ (three-phase).

W. G. R.

366. *Protection of Secondary Circuits from Fire Risks.* **C. T. Hutchinson.** (Amer. Instit. Elect. Engin., Trans. 16. pp. 427–437. Discussion, pp. 437–450. August and September, 1899.)—*In this paper* the question of protecting

secondary circuits from the dangerous consequences of an abnormal potential in these circuits caused, *e.g.*, by the failure of the insulation between the primary and secondary coils of transformers, is very fully discussed. The author strongly advocates grounding the secondary permanently, as the only sure way to prevent the potential above earth of the secondary system rising above the normal potential of the circuit.

In the discussion, **E. Thomson, C. M. Goddard, Steinmetz, Bell, J. I. Ayer, W. Brophy, Puffer, C. W. Rice,** and **Kennelly** spoke in favour of grounding the secondaries, and **Goldsborough** against. It was resolved *inter alia* that the Amer. I. E. E. should officially recommend the National Board of Fire Underwriters to pass a rule permitting or requiring the permanent grounding of one wire of secondary systems, under suitable restrictions. C. K. F.

367. *Distribution of Electricity.* **C. D. Taite.** (Electrician, 43. p. 371. Discussion, p. 372, July 7, 1899. Paper read before the Municipal Electrical Association.)—In alternate-current systems isolated transformers are being replaced by a number of transformers banked in substations to the extent of 200 kilowatts each. Transformers thus connected directly in parallel frequently do not share the load in proportion to their outputs, and are consequently liable to overloading. A demand indicator should be connected in circuit with each. Disconnecting boxes should be employed at frequent intervals. The pillar-boxes of the Southport station are described. The cost of making service connections is very high, amounting to £11 or £12 per consumer. This is analysed, and the possibility of reducing it discussed. The generating expenses of electric lighting stations have almost reached a minimum, and cheapening in future is to be looked for in the reduction of capital and standing charges. A discussion followed. L. B.

368. *Electric Transmission.* **J. Swinburne.** (Instit. Civ. Engin., Proc. 138. pp. 478–481, October, 1899 (Abstract); also Engineer, 87. p. 574.)—The author considers the questions of the copper and insulation used in leads for long distance transmission of energy. Taking the same maximum voltage (10,000) and working at the same current density, the author gives the following comparative table for the power transmitted in the various cases:—

Current.	Output in Kilowatts.		
	Case 1.	Case 2.	Case 3.
Direct	4000	2000	2000
Single Alternating	2824	1412	1412
Double ,,	1650	1650	1170
Triple ,,	5000	2824	2824

Case 1 referring to systems earthed at a middle point; Case 2 to systems with one conductor earthed; and Case 3 to systems where the difference between no two conductors exceeds 10,000 volts. W. G. R.

369. *Electrical Transmission and Distribution.* **H. F. Parshall.** (Instit Civ. Engin., Proc. 138. pp. 486–487, October, 1899 (Abstract); also Engineer vol. 87. p. 612.)—An increase in the pressure of overhead lines leads directly to economical transmission, so far as concerns the cost of conductors and th

efficiency. For underground cables 20,000 volts may be taken as the present safe limit.

A number of small substations are commercially more economical than the same number of complete generating stations, because they occupy less space, and are free from objectionable vibration and noise. They involve lower efficiency in transformation, higher first cost, and heavier charges for attendance, but a saving is effected both in feeders and distributors, and feeder losses are smaller.

With rotary converters it is advantageous to connect for six-phase transformation instead of three-phase. Early difficulties with the rotary converter have been largely overcome by more careful design both in the converter itself and also in the prime mover, in which the production of a constant angular velocity is most important. E. K. S.

370. *Use of Batteries and Boosters.* **P. Girault.** (Ind. Élect. 8. pp. 213–216, and 368–369, August 25, 1899.)—The author states that every continuous-current central station for the distribution of electric energy should use batteries and boosters, since their use tends to keep the load on the generators constant. Series boosters run at constant speed and, connected to the different feeders, keep the pressures at the centres of distribution equal to that at the station. The generators, being then under constant load, should be simple shunt machines. W. G. R.

371. *Double Current Generators for Power Transmission.* **E. Thomas.** (Electrician, 44. pp. 190–191, December 1, 1899.)—After reviewing the points and opinions which are usually taken into consideration when selecting a system of distribution, the author shows where double-current generators are likely to prove most useful, viz., as intermediaries in stations where both direct-current and alternating-current plant is installed, and also in those stations where the greater part of the load is of one class only. They are also the most economical generators suitable for a long-distance, lightly loaded railway line, the direct-current side feeding the station end of the line and the distant parts being fed from rotary converters in substation supplied from the alternate-current side.

The armature reaction and the number of poles required tend to reduce the efficiency of working, the best results being obtained with large units and a frequency of 25 cycles per second. E. D. P.

372. *Electric Mining Plant.* (Elect. World and Engineer, 34. pp. 445–447, September 23, 1899.)—At Santa Rosalia, Southern California, a copper-smelting works has been equipped with an electrical installation consisting of four engines aggregating 1,500 H.P. and driving three-phase inductor alternators. Condensing water is obtained from the sea, rain being almost unknown. Power is transmitted at 5,200 volts to the copper mines, twelve miles distant, and to Santa Rosalia, where it is transformed down to 380 volts for industrial purposes. For lighting the town it was found necessary to convert to direct current, on account of the irregularities of pressure caused by the starting of induction motors. Details of the machinery are given, with illustrations.
A. H. A.

373. *Working Costs of Isolated Electrical Installations.* **P. R. Moses.** (Amer. Instit. Elect. Engin., Trans. 16. pp. 825–847. Discussion, pp. 847–868, June and July, 1899.)—This paper deals with the cost of electricity in typical

buildings in New York City, U.S.A., as compared with the cost of supply from central stations. The cost of electricity is defined as the difference between the cost of supplying the other requirements of the building alone and the cost of supplying both these and electricity from private plant. Interest and depreciation are included at 5 per cent. each. Numerous load curves, taken from various types of building, and a mass of data in connection with the detailed costs of operation, are given. A few of the results are summarised below :—

Type of Building.	Total Cost per kw. Hour.	Coal per kw. Hour.	Kind of Load.	Approx. Annual kw. Hours.
Large hotel	0·83d.	3·4 lbs.	Fluctuating	825,000
Small hotel	1·22	8·37	Steady	100,000
Apartments	2·35	7·0	,,	55,000
Large store	1·42	9·25	,,	200,000
Small store	2·05	12·8	,,	50,000
Large office building	2·18	9·4	Fluctuating	158,000
Small office building	2·53	7·25	,,	40,000
Loft building	1·30	8·0	,,	100,000

The average price of electricity supplied from the Edison central stations was 5·3d. per kw. hour during 1898. Full details are given of the methods of obtaining the necessary data and of the installations themselves.

In the discussion **H. W. Leonard** preferred 15 per cent. for interest and depreciation, and pointed out the value of the space occupied by the plant. **A. Williams** remarked that exhaust steam for heating was required in the morning, but not in the evening, when the supply was at a maximum, and gave instances where the station supply was proved to be the cheaper, and where the energy actually generated was far less than had been believed. He also disputed various conclusions of the author, and gave instances of gas-driven plants, of which the cost of working exceeded the central station charges. **C. P. Steinmetz** said that for the greatest economy elevators should be balanced so that the motor overcomes the friction only. In a communication **C. Blizard** supported the use of storage batteries in isolated plants. A. H. A.

374. *Electric Power in Steel Works.* (Amer. Electn. 11. pp. 456–458, October, 1899.)—A description of the electrical plant used at the works of the Illinois Steel Company, Chicago. In addition to the ordinary electric travelling cranes, of which there are several, electricity is the power employed for charging the open-hearth furnaces, shifting tables in the slab mills, and for magnetic lifts and trolleys in the plate mills. Descriptions and illustrations are given of these machines. In the generating station are two Westinghouse machines, a 400 kw. and a 300 kw. supplying direct current at 250 volts pressure. Six Thomson-Houston machines are provided for the arc-lighting and are driven in pairs by 100 H.P. Westinghouse motors supplied from the main generators. There is also a 60 kw. alternate-current machine for the incandescent lighting. It is estimated that a saving of 50 per cent. in the cost of power is effected by the substitution of electric power for the steam power formerly used. E. D. P.

375. *Mt. Whitney, Cal., Transmission Plant.* **D. H. Fry.** (Elect. World and Engineer, 34. pp. 648–649, October 28, 1899.)—An illustrated description

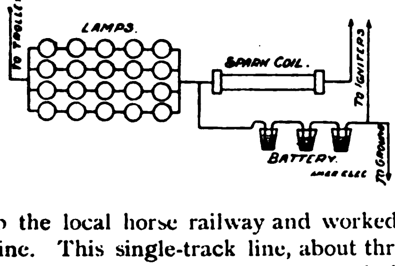
of these works is given, dealing more particularly with the hydraulic power supply.

The Kaweah River is naturally adapted for the work required; a natural granite dam forms the headworks, and the lowest mark the river has yet reached will supply a flow far in excess of the maximum required at the works.

The pool is tapped by a tunnel through rock, and from this starts a wooden flume, 30,000 feet long, with a fall of 1 in 200, 3 feet wide, and 2 feet deep. The pipe line, 3,300 feet long, has a fall of 1,325 feet, is 20 inches diameter at the penstock, reducing gradually to 19 inches at the receiving end, is made of lap-welded steel, and instead of the usual bolted flange joints, has one end of each pipe length belted and a riveted joint made. Details are given of the method of erecting and the principles embodied in the design of the hydraulic plant.

The generating units consist of three three-phase, 450 kw., 440 volts Westinghouse alternators; the water motors being of the Pelton type of 700 H.P. each. The exciters are driven by belts from the main machines, the author having found that in works working with high heads of water the small wheels necessary to drive exciters separately are not to be relied on. The transmission-line pressure is 17,300 volts. Five substations are used, and from each the energy is distributed at 2,000 volts pressure. An apparatus invented by Lacey is used on some of the private circuits. It consists of an electromagnetic current interrupter which, when placed in series with the main circuit and adjusted, causes the lights on that circuit to flicker should the number allowed be exceeded. When the excess of current is cut off then the interrupter is steadied by its control, which can be adjusted for any current. It is more convenient and sensitive than fuses, and is useful for those customers who pay on the flat-rate system. E. D. P.

378. *Gas-Driven Traction Power Station.* (Amer. Electn. 11. pp. 206–208, 1899.)—This is an example of the successful regulation of gas-engine driven dynamos for the extreme load changes on a small electric road. The trunk lines of the Long Island Railroad Company do not run close along the shore. The Port Jefferson branch line follows an elevated tableland, and the nearest point is about two miles from the village of Huntington. The Railroad



Company bought up the local horse railway and worked it electrically as a feeder to the main line. This single-track line, about three miles in length, runs from the shore to the village of Huntington, and rises 165 feet to the station with gradients up to 4½ per cent., or 1 in 22.

The power plant at the shore end consists of two Westinghouse three-cylinder vertical gas engines, each of 50 nominal H.P., supplied from the local gas company. The regulation of speed is by varying the amount of the charge, instead of the hit-or-miss method of governing. Current for the electric igniters is taken from the 500-volt dynamos, and passed through 20 incandes-

cent lamps connected in four groups of five lamps each in series (see fig.) and thence to the spark coil and igniters. The high voltage tends to keep up an arc across the igniter contacts and causes "back fire" in the mixing chambers when the admission ports are opened. To overcome this there is a shunt around the spark coil and igniters, consisting of a battery of three glass tumblers with lead strips bent over and dipping into dilute sulphuric acid. These take the current when the igniter circuits are open, reducing the voltage across the igniters to about 7 volts, and absorb a charge which is given out again to the igniters when their circuits are closed. When starting the engines the igniters are supplied by a battery of 12 Edison-Lalande primary cells.

Each gas engine is belted to a 87½ kw. Westinghouse four-pole 550-volt dynamo. There is a storage battery of 265 chloride accumulators, having a maximum discharge rate of 44 amperes for short periods, and worked directly in parallel with the dynamos without booster or end cell switch. The compound winding reduces the voltage of the dynamo as the load rises, so that the battery takes the greater part of the load fluctuations.

The line has been running since June 20, 1898, with one car in winter and three open cars in summer, and has carried 5,000 passengers in a single day. The ordinary car mileage is two hundred miles per day, and the gas consumption 46 cubic feet per car mile, the total working expenses with gas at 90 cents per 1,000 cubic feet, and including the wages of motor men and conductors, being 13 [6½d.] cents per car mile. W. R.

377. *King's Lynn Electricity Supply Works.* (Electrician, 43. pp. 722–729, September 15, 1899.)—In this public supply station producer gas is generated and utilised to drive Otto cycle gas engines belted to continuous-current dynamos which supply, through a regulating battery of accumulators and a balancing transformer, current at 2×200 volts to a three-wire distributing network.

A 9 H.P. vertical boiler generates steam at 80 lbs. per square inch for four gas generators. The steam is superheated in pipes by the hot gas between the producers and coolers. Each generator makes, from Welsh anthracite, 18,000 cubic feet of gas per hour at a pressure of 1·5 inch of water, and having a calorific value of 145 British thermal units per cubic foot. The gas, cooled in vertical cast-iron pipes, passes through a hydraulic box and coke scrubber provided with a continuous supply of water, and next over trays of sawdust and chips to gasholders. The gas engines, of Fielding and Platt, work on the Otto cyc'e. Each engine has duplicate ignition tubes, one of which is connected to the town gas mains. To start the engine with the piston on working stroke, gas is first admitted to the combustion space, and the mixture escapes by an outlet near the flame for ignition tube. When the colour of the flame indicates that only gas is escaping the outlet is closed, the supply is shut off, and compressed air admitted from a small reservoir, into which it is pumped by the engine. The compressed mixture moves the piston forward, and then explosion takes place and the engine is started.

Each engine is of 65 B.H.P. and drives a 40 kw. dynamo. At full load the consumption is not to exceed 85 cubic feet of gas per hour per I.H.P., and for this not more than 1 lb. of anthracite coal is to be used per hour in the producers. The speed is regulated on the hit-and-miss plan, and the fluctuation of volts is not greater than 1 per cent. at full load and 2 per cent at quarter load, and the speed must not increase 5 per cent. when half of full

load is thrown off. The dynamos are two-pole, overtype shunt machines, each having 160 commutator segments, and at 150 revolutions per minute can develop 88 amperes at 450 volts, and when charging batteries 80 amperes at 540 volts.

The battery, 225 cells of the chloride R 17-plate type, has capacity of 400 ampere hours for 10-hour discharge and 320 ampere hours for 4-hour discharge down to 1·85 volts per cell, and can stand 150 amperes for short periods. The pressure is regulated by switching cells in and out; also by iron resistance in series with the feeders. The middle wire is directly earthed at the station. Balancing transformers are in a substation in the centre of the district, about a quarter of a mile from the generating station. The two balancers are two polar, both armatures wound on the same drum with only one field magnet. At 1,250 revolutions per minute a balancing current of 50 amperes is generated in either armature. The feeders are branched, so that each serves two feeding-points.

A special reversing junction-box is provided at every fifty yards for service connections from the triple-concentric distributors. The street lighting is by both incandescent and arc lamps. The charge for light is 5½d. per B.T.U., and for power 3d. per unit. W. R.

378. *Perth (W.A.) Electricity Works.* (Elect. Rev. 45. pp. 927–928, December 8, 1899.)—Three-wire direct-current system with accumulators is used, and the rapid progress of electric lighting in the town is dealt with. An interesting account is given of the rapid change-over of the whole system, both on the distributing network and in the station, from 220 volts maximum to 440 volts maximum. E. D. P.

379. *Albion Power Company's Water Power Transmission Plant.* **O. E. Dunlap.** (Elect. Rev. 45. pp. 928–930, December 8, 1899.)—Description of the works of the Albion Power Company. The generating station at Waterport is 6¼ miles from Albion. A dam 200 feet long and 12 feet high is built across the Old Orchard Creek, forming a large reservoir, by setting the river back for three-quarters of a mile. The available fall is 18 feet. The flume is built into the earth bank, and consists of a steel framework filled in with concrete to a thickness of about 2 feet. Two McCormack wheels are installed, 250 H.P. and 175 H.P., each driving a three-phase, Stanley inductor type, alternator. The machines are designed to run in parallel and feed the transmission line at a pressure of 6,600 volts. The exciters are driven by bells from the main generators. The overhead line consists of three seven-stranded aluminium conductors, supported on triple-petticoated glass insulators, the poles being 30 feet high and 100 feet apart.

The pressure is transformed down to 1,100 volts at the Albany substation, which contains a 75 H.P. inductor alternator of similar type to those at Waterport. This is provided with an exciter and also a three-phase starting motor of 5 H.P. to bring it up to speed, when it is run off the 1,100-volt mains as a motor to drive a Brush arc machine for street lighting. At this substation there is also installed a steam-driven plant as a reserve, having a capacity equal to that of the works at Waterport. The town circuits are divided into three sets, each being fed by one leg of the three-phase system, transformed to 110 volts. A three-phase line is also run round the outskirts of the town to provide light and power. E. D. P.

380. *Blackpool Trams.* (Elect. Rev. 45. pp. 859–868, September 1, 1899.)—Disfigurement of the streets is avoided by using short bracket arms and lor

(20-foot) trolley poles with special springs. Two Parson's turbines supply 400 H.P. at 500 volts, each turbine driving two dynamos at 250 volts coupled in series. Quin's maximum and minimum cut-outs disconnect each section of wire (1) in case of a short circuit, and (2) in case a trolley wire is broken, by means of shunt and series coils acting in opposition. Askham and Wilsons made the points and crossings, Lowdon and Co. the 152 poles of mild steel, which are butt-welded, 28 feet long, 8 inches outside diameter at the foot, 5 inches at the point, and $\frac{7}{16}$ inch thick. They are slipped into a cast iron plinth (by McFarlane) and traversed by the cross-arm tube, 2 inches outside diameter and $\frac{1}{4}$ inch thick, which supports a 000 copper wire having 28 tons per square inch tensile strength. The cars, by Milne and Co., carry 86 passengers. M. O'G.

381. *Electric Railway Systems of Quebec.* (Street Rly. Journ. 15. pp. 495–502, August, 1899.)—The city of Quebec is so hilly that it was found impossible for the electric cars to ascend some of the streets. To overcome this difficulty a trestle was adopted, which ascends the first portion of the hill obliquely with a grade of 7 per cent. On reaching a certain point, where the trestle meets one of the cross-roads, a curve was located on a level section on the trestle, after which the grade is 11 per cent. for 300 feet, then 4 per cent. till the Upper Town is finally reached.

Owing to the heavy snowfalls in this region it is necessary to employ sweepers, levelling ploughs, and box sleighs. The total equipment for the disposal of snow consists of six sweepers, each equipped with two 30 H.P. traction motors, and another motor of the same type placed in the cab for revolving the brooms, several horse-drawn levellers, and numerous box sleighs.

The brakes employed on the cars consist of ordinary brake shoes made of specially soft cast iron, with the flanges perforated to permit the mud to percolate freely, and provided with a brake leverage of 10 to 1. Under these conditions skidding is very uncommon. The wheels are 33 inches in diameter. The brake shoes have an average life of three months. The average number of wheels worn flat is only 14 per cent. of the total number of worn-out wheels, and these are mostly due to a slippery track in winter. A test was made recently to ascertain the current consumption in ascending the heavier grade, one of 14·15 per cent., 90 feet long, with a 40-foot radius curve on the summit, half of which is on the hill. Under the most favourable summer conditions the maximum current drawn by the two motors during the ascent until the curve was reached was 65 amperes at 520 volts; then after being switched off on reaching the curve and again thrown on, the maximum reading was 130 amperes, still at 520 volts, for it is customary to throw the power completely off the moment the car enters the curve, and as the car commences to lose momentum the power is thrown on again. The average speed of the car was 4·5 miles per hour, and the estimated weight 9 tons. Under average winter conditions the current consumption rises to nearly 100 amperes on the grade and to about 195 amperes on rounding the curve.

In descending all heavy grades the motor-men are obliged to come to a standstill at the top to ascertain if the brakes are in good working order, after which the speed downhill must not exceed four miles per hour, so that a stop may be made if necessary on the hill. As all the excessively steep grades are short, the time lost in going slow is very small.

The average power consumed in summer, as obtained by the integrating wattmeter in the station, is 8·8 kw. per car per hour, the average for th

whole year being about 9·5 kw. per car per hour. The average mileage per car per day is 106.

The trolley wheel is of soft brass, $4\frac{1}{4}$ inches in diameter, and as it is carefully greased every day it seldom leaves the trolley.

Its average life is 10,000 miles, or about 95 days. Commutators run 25,000 miles before being sent to the lathe. The greatest wear on the commutator has been a decrease of $\frac{3}{16}$ inch in the diameter; the average has been $\frac{1}{8}$ inch. The brushes used are of the Le Valley Vitæ manufacture. L. J. S.

382. *Electric Tramway in Batavia.* **H. Lippegaus.** (Elektrotechn. Ztschr. 20. pp. 742–747, October 26, 1899.)—A description of the first electric tramway to be established in the Dutch possessions of the Malay Archipelago.

In order to guard against injury to this power station from the slight earthquake shocks which are prevalent, the foundations are strengthened throughout by a framework of wrought-iron girders.

The boilers, three in number, are of the double drum type, each 7 feet diameter, the upper drum $19\frac{3}{4}$ feet and the lower drum 23 feet long. With a heating surface of 1,070 square feet and Australian coal, the normal evaporating capacity is 3,300 lbs. per hour. The furnaces are so arranged that petroleum waste may be burnt instead of coal.

The three engines are of the McIntosh and Seymour horizontal tandem compound type, each 150 H.P. at 285 revolutions per minute. The dynamos are six-pole machines by the Union Elektricitäts-Gesellschaft, Berlin, economiser by Green, Worthington pumps, &c.

These lines (gauge 1.18 metres, and of lengths 5 miles, 8 miles, $\frac{3}{4}$ mile) are laid to one side of the public roads, the rails resting on sleepers of Dyatti wood, an Indian oak which resists the attacks of the white ant. There are eight feeders. The rails are used as return, being copper bonds 0·16 square inch area.

[A description, more liberally illustrated, appears in the Electrical Engineer for November 17th and 24th and December 8, 1899.] E. K. S.

383. *Coblenz Electric Tramway Station.* (Elektrotechn. Ztschr. 20. pp. 635–637, September 7, 1899.)—A station laid down by the Union Elektricitäts-Gesellschaft, of Berlin. The generating plant consists of (*a*) two direct-current 150 kw. six-pole dynamos, giving current to the trolley line direct at 500 volts, and (*b*) two three-phase alternators generating current at 2,080 volts for the substations. All the machines are direct coupled and run at 150 revolutions per minute, there being three engines, one with a dynamo, one with an alternator, and the third having both a dynamo and alternator coupled at either end of the crank shaft. There are two sets of accumulators—one a buffer battery consisting of 275 cells connected to the trolley wires, and the other having 65 cells, being in the exciting circuit of the alternators. Three motor transformers are provided, (*a*) to enables the alternator to deliver current to the station end of the lines, and (*b*) for charging the exciting cells or exciting direct from the direct-current dynamos. The whole plant is well and simply arranged. E. K. S.

384. *Reichenberger Tramway.* **M. U. Schoop.** (Zeitschr. Elektrotechn. Wien. 17. pp. 467–473, September 10, 1899.)—A description of a tramway in which great use is made of buffer batteries. The accumulator cells are by G. Hagen, and curves are given in the article showing the advantages of the method of working in getting over the peaks of the load curves and for

regulation. Particulars of two tests of the generating plant are given as follows :—

Test of two Lancashire boilers; steam pressure, 8 atmospheres; two horizontal compound condensing engines (Breitfeld, Danek and Co.), and two eight-pole, belt-driven dynamos (Schukert and Co.).

	Normal load.	Overload.
Duration of test in hours	7	8
Total water evaporated	kg. 8,488	12,420
Used in boiler-house	kg. 114	114
Used in engine-house	kg. 95	80
Balance	kg. 8,279	12,226
Indicated H.P. of engine	152·8	192·2
Steam used per indicated H.P. hour	kg. 7·74	7·95
Electrical H.P. on dynamo pulley	128·35	166·4
Brake H.P. of engine	132·2	171·4
Efficiency of dynamos	90°/o	91°/o
Loss in belt drive	8°/o	3°/o
Efficiency of engine	86·5°/o	89·2°/o
Revolutions per minute	126	125
Heating surface of boilers	80 sq. metres.	
Grate area of boilers	1·65 sq. metres.	
Water evaporated per square metre of heating surface per hour	kg. 15·2	19·4
Coal burnt per hour	kg. 162	227
Coal used per square metre of grate area per hour	kg. 98·3	137·8

E. K. S.

385. *Accumulator Traction (Louvres to Vincennes, Paris).* **A. Monmerqué.** (Électricien, 18. pp. 104–108, August 12, 1899. Extract from the Revue Générale des Chemins de fer.)—Gradients and details of this scheme, which is already commenced, are given. Power up to 2,000 kw. is provided for, the present installation of 1,600 kw. being divided into five sets, three direct coupled dynamos with horizontal engines at 70 revolutions per minute and two dynamos coupled to a Laval turbine—the latter being used on account of the great rapidity with which it can be started up. Circulating and air pumps for condensers are electrically driven and take 6 per cent. of the output. The voltage of the direct coupled sets can be varied by the field alone from 540 to 580 volts. The armatures are gramme rings rotating outside an eight-pole field —the periphery constitutes the commutator. The Laval turbine drives, through a bronze gear-wheel and pinion, a dynamo which has two armatures coupled in series. The set yields 200 kw. The gear is in a grease-tight wrought-iron case. The boosters for accumulator charging, &c., are 40 kw. series dynamos driven by shunt motors taking current from the main board; they are four in number, one on the positive and one on the negative pole of the two pairs of feeders. Eighty-five cars having fifty-two seats are proposed. The motor cars weigh 18 tonnes, trailers, 8·3 tonnes. The accumulators are specially ventilated and weigh from 4,600 to 4,700 kgrs. The cells will be charged in fifteen minutes, and their energy efficiency will not be less than 70 per cent.; their specific gravity capacity is to be 6·2 watt hours per kgr. of plates, *i.e.*, 8·9 watt hours per kgr. of cell. In exceptional circumstances 18·5 *watt hours may* be required on the Louvre-Vincennes route. M. O'G.

386. *Electric Transmission between Bozen, Meran, and Nachbarote.* **O. v. Miller.** (Elektrotechn. Ztschr. 20. pp. 615–619, August 31, 1899.)—Detailed description of an important three-phase transmission plant laid down by Ganz & Co. The power station is situated 5 kilometres from the town of Meran (Austrian Tyrol), and is equipped with six turbines each of 1,000 H.P., working under a head of water of about 66 metres. The three-phase alternators are direct driven at 320 revolutions per minute, and each is fitted with a four-pole exciter. Four of the alternators generate current at 3,600 volts, and two are arranged to give either 3,600 volts or 10,000 volts, the latter pressure being required for the long-distance line between Meran and Bozen. The switch-board is so arranged that two of the alternators can be connected on to the 3,600 volt 'bus bars for the electric lighting of Meran, or on to 3,600 volt special 'bus bars for power to a carbide factory.

The disposition and lengths of lines and the amount of energy required for lighting and power is as follows :—

Three-phase line at 3,600 volts for Meran and Nachbarote.
Three-phase line at 10,000 volts for Bozen and Zwischenork.
Three-phase line at 3,600 volts for the electrochemical factory.

Area of each of the three conductors to Meran 6·5 square mm., and to Bozen 6 square mm.

Total length of main transmission line, 39 kilometres.
Total length of overhead distributing cables, 30·4 kilometres.
Total length of underground cables, 88·2 kilometres.

Street lighting, 83 arcs, 770 incandescents.
Private lighting, 21 arcs, 24,500 incandescents.
Motors, 45 H.P.
Electrochemical factory, 2,000 H.P.

A very clear diagram of connections of the power-house main switch-board is given, and the plan and elevation of the station indicate the ample space which is provided behind the board for the extra high tension switches and 'bus bars, Siemens-Halske horn lightning arresters, &c.

Three cross-sections are given of the transformer substation at Gries, near Bozen, where the pressure is reduced from 10,000 to 3,000 volts, and six cross-sections of a street switch pillar.

The charge for light has been fixed at 7 florins (11s.) per 16 c.p. lamp per annum, and for motors at 50 florins (£4) per H.P. per annum.

E. K. S.

387. *Cost of Electric Traction.* **G. C. Cuningham.** (Instit. Civ. Engin., Proc. 138. pp. 485–486, October, 1899 (Abstract); also Engineer, vol. 87, p. 611.)—The cost of horse traction may be taken as varying from 3½d. per car mile in towns with easy gradients, to 5d. in hilly towns. In overhead electric traction, with economical engines and boilers, the cost of wages, fuel, water, oil, &c., in the power house, together with maintenance and repairs of the machinery, should be less than ½d. per car mile in level towns and but little more than ½d. in towns with steep gradients. On the Montreal Electric Street Railway, for example, with coal at 9s. per ton, the cost of producing current is a little under ¼d. per kilowatt hour, and the cost per car mile less than ½d. in the open months of the year. The coal consumption is 3·48 lbs. per kilowatt hour, or 2·60 lbs. per E.H.P. hour

during several months; while the average for a whole year is only 2·75 lbs. per E.H.P. hour.

The *whole cost* of working a large electric tramway should be well under 5d. per car mile, but this result can only be obtained where the cost of the current at the generating station is cut down to a minimum by the use of engines and boilers which do their work with a low consumption of fuel. It is, in fact, upon the construction and economical working of the machinery in the power house that commercial success depends. E. K. S.

388. *Comparative Costs of Cable Electric and Horse Traction in New York.* (Street Rly. Journ. 15. pp. 579–580, September, 1899.)—In Abstract No. 524 (1899) was given the comparative results of the expenses and receipts of the cable lines, the electric (underground conduit) lines and the horse railway lines of the Metropolitan Street Railway Company of New York City. The present article gives in comparison with these figures those of the corresponding financial year just ended. The comparison is the more valuable, inasmuch as the track mileage of the system is the same this year as last, the results not being complicated by the purchase of new lines or the building of extensions.

In the last year the Company ran its cars over the same track nearly 42 million miles as against 35 million miles in the previous year, the new cars being, moreover, nearly double the capacity of the old. The passenger receipts jumped nearly 25 per cent. as a consequence, while the receipts per car mile were actually increased from 29·7 cents to 30·7 cents, or 3 per cent. The traffic of the cable lines fell off about 10 per cent., and of the horse lines about 30 per cent., while the electric lines carried three times as many passengers in 1899 as in 1898, and their receipts per car mile increased from 26·99 cents to 31·23 cents.

The percentage of operating expenses to passenger receipts of the three motive powers compare as follows :—

	1898. Per cent.	1899. Per cent.
Cable	47·8	50·8
Electric	37·9	38·3
Horse	65·3	69·8
Total	53·3	49·4

A general financial statement in tabular form accompanies this article, from which the following has been obtained :—

	1898.	1899.
Receipts from all sources	$11,076,021	13,525,524
All operating expenses	$5,620,484	6,408,711
Earnings from operation	$5,455,537	7,116,813
Per cent. operating expenses to total receipts	50·7	47·4
Fixed charges	$3,609,966	4,477,757
Dividends paid	$1,500,000	2,471,675
Surplus over dividends	$345,570	167,381

L. J. S.

389. *Railway Power Distribution over Large Areas.* **A. H. Armstrong.** (Street Rly. Rev. 9. pp. 579–580, September 15, 1899.)—A paper read before the Street Railway Association at New York, and descriptive of the power supply to the various electric street railways operating in and around Buffalo.

For such a heavy load and extended area *a single generating station* was

not looked upon as desirable on account of the great expense of the feeders; whilst the employment of boosters as a permanent means of replacing feeder copper where heavy overloads may be of long duration is also very objectionable. Overloads of short duration, especially if they are local, can very well be taken care of by boosters, but the cost of the energy lost in boosting long daily overloads would be very considerable.

Having *two separate generating stations* reduces the feeder copper, but the first cost and cost of operating two stations is greater than that of operating a single station of the combined capacity of the two.

The third method by rotatory converter substations was therefore adopted because it permits substations to be located wherever there is the greatest demand for power. The small section high pressure transmission line can be carried underground to any locality, and as the station itself requires no boilers or engines it may be located in busy neighbourhoods. The largest congestion of cars, and hence the largest demand for power, exists in the business districts, and it is owing to the possibility of placing machines close to the powers of greatest demand that makes the substation system especially adapted to the operation of large street railway systems.

The labour charge is higher, but it is pointed out in the paper that the number of attendants need be only two for a substation of a capacity of say 1,200 kilowatts. It is now proposed to shut down the present power house and keep it as a reserve; the whole of the system of the International Traction Company in Buffalo, Niagara Falls, Tonawanda, and Lockport being then driven from rotary converters fed by the Niagara Falls power. There are to be six substations as under:—

Substation.	Maximum Output.	Converter Installed.	Ultimate Capacity.
No. 1	760 kw.	800 kw.	1,200 kw.
„ 2	870 „	800 „	1,200 „
„ 3	1,230 „	1,200 „	1,600 „
„ 4	870 „	800 „	1,200 „
„ 5	890 „	800 „	1,200 „
„ 6	1,600 „	1,600 „	1,600 „
	6,220 kw.	6,000 kw.	8,000 kw.

The maximum output is for the winter months when car-heaters are in constant use.

The step-down transformers in the various substations take three-phase current at 10,500 volts, and reduce it down to 375 volts, which corresponds to 600 volts direct current on the commutator of the rotatory converter. The transformers are connected in delta, so that the disabling of one transformer of a set does not throw the converter out of service. Direct current-blower sets are provided in duplicate, and feed into a common air chamber from which individual transformers, &c., draw their supply. Artificial reactance is introduced between the transformers and converters to enable the latter to regulate with varying loads. A special starting set consisting of an induction motor coupled to a dynamo has been installed in two of the substations, which permits the starting of the converters from the direct current end, and ensures bringing them into synchronism in a minimum of time with the right polarity. The converters in adjacent substations can then be started from the direct current feeder system.

E. K. S.

390. *Buffer Batteries for Electric Traction.* **L. Gebhard.** (Zeitschr. Elektrotechn., Wien. 17. pp. 418–428, July 30, and 429–433, August 6, 1899.)—This is a paper read before the Elektrotechnischer Verein, Wien. In designing traction stations it has been usual to make the dynamos large enough to take the maximum loads allowing a suitable stand-by, and to use a battery merely to regulate the voltage and supply the light load when the plant is shut down. It is then an extra capital charge, and is therefore made as small as possible. The true use of the battery is rather to allow the plant installed to be reduced till it is just sufficient to take the average load, relying on the battery to supply the additional demand and to act as the necessary stand-by, thus keeping the load factor at 100 per cent., and effecting a large saving both in capital outlay and in generating expenses. A specimen traction-load curve taken from the Remscheidt station is given. In large stations the advantage of a buffer battery is not so marked owing to the more even load curve demanded. In Hamburg, for instance, with an average load of 2,000 amperes, the maximum momentary output reaches only 2,400, which could easily be obtained as an overload from a 2,000 ampere plant. But even here the avoidance of sudden shocks on the generators is very advantageous, and a battery with a capacity of 1,600 amperes for one hour has been installed. In Leipzig, in spite of the large output, a saving of 30 per cent. was effected in the generating expenses by the installation of a battery of similar capacity. A graphic method is described for determining the periodic variations in the load curve, and thence the average load, from the profile of the line and the schedule of the service of cars. To determine the H.P. required by a car at any moment the following formula is given :—

$$\text{H.P.} = \frac{6wv(1{\cdot}25\mu + S)}{E}$$

Where μ, S and E are the traction coefficient, the gradient and the efficiency of the motors and gear, all expressed as percentages, w the weight of the car in tons, and v the speed in miles per hour. The coefficient 1·25 is introduced to cover variations in the condition of the track, losses in the starting and regulating resistances, &c. The traction coefficient μ may usually be taken as 1·2 per cent.

From this graphic solution the following rule is demonstrated : The average power required for all the cars on a given track can be found by dividing the work required to propel one car for the double journey by the scheduled time in seconds between the cars. And this is the maximum output required from the dynamos if an efficient buffer battery is employed. It should be large enough to supply this average load itself for one hour, and its internal resistance, which depends largely on its capacity, should be small enough to keep the voltage from falling too low on a momentary rush of current. The drop of voltage owing to the battery resistance should not be more than 5 per cent. when giving an extra output equal to the average output of the plant. These conditions determine the size of battery required.

For all gradients less in magnitude than the traction coefficient the power used in going up is saved in the descent on the return journey. Hence the calculation of the average power required can be simplified without reducing its accuracy by neglecting all such gradients. The loss of power in the starting and regulating resistances is not taken into account in the above formula. But such losses are amply covered by the 25 per cent. allowance in the traction coefficient, particularly if the stopping-places are sufficiently definite to avoid frequent unnecessary use of the brake.

Details are given (p. 429) of the capital and working expenses estimated for a four-mile tramway between Haspe and Gevelsberg, in Westphalia, showing the great economy attained by the use of a large battery. L. B.

391. *Stationary Accumulators for Traction Work.* **G. Brandt.** (Elektrotechn. Ztschr. **20.** pp. 780–782, October 19, 1899.)—In order to arrive at some reliable experimental data regarding the action of accumulators as regulating devices in traction plants, the author carried out a number of tests for Siemens and Halske. In considering the action of a secondary battery the author introduces the term *characteristic resistance*, which he defines as the ratio of the difference between the E.M.F. and P.D. to the current (the E.M.F. considered being the *steady* E.M.F. which the battery reaches some time after breaking the circuit, and not the instantaneous E.M.F. immediately after the break). This quantity is variable, and it is a matter of great importance to find what factors determine its value. The author's experiments show that the characteristic resistance of a battery is independent of the current, but that it depends on the time during which that current has been allowed to flow, and that the effect of a momentary preceding charge is almost entirely wiped out during the first minute of discharge. The main benefit resulting from the employment of a suitably chosen battery is the saving of fuel consequent on the fact that the engines and dynamos are kept working at their point of maximun efficiency, the fluctuations of load being taken by the battery. The author's experiments lead him to the conclusion that the best mean E.M.F. of the battery depends solely on the type of battery used, and not on the particular conditions of working. In the case of the batteries tested by the author, the best regulating effect was obtained by making the mean E.M.F. of each cell 2·07 volts. From this the required number of cells may be at once determined. A. H.

392. *Energy-Economy in Electric Traction.* **M. Bricard.** (Écl. Électr. **20.** pp. 5–10, July 8, 1899.)—The author considers the waste of energy in braking in a manner similar to that given in Abstract No. 346 (1898). High accelerations should be used.

With electric vehicles two cases arise: (1) where the tractive effort is limited by adhesion (as on rails), (2) where the adhesion is always in excess (as on roads). The author discusses these in detail and concludes that, from the point of view of energy consumed, the tractive effort should be a maximum and the acceleration constant (*i.e.*, constant current, obtained by starting with a large resistance in series and gradually cutting it out as the speed and back E.M.F. rise), but considerations of plant efficiency lead largely to the use of constant (full) voltage. E. H. C.-H.

393. *Combined Single-Phase Alternating and Continuous Current System of Working Electric Railways.* **F. Eichberg.** (Zeitschr. Elektrotechn., Wien. **17.** pp. 318–327, June 14, 1899.)—Single-phase alternating current is picked up from the trolley line and led to a single-phase motor on the car. The car also carries a continuous current motor and a set of accumulators which can be brought into use at starting up, &c.

The paper contains particulars of tests on two trains fitted in this way, the first on a line having a maximum and mean gradient of 20 and 13 per cent. respectively, and the second on a line having gradients 5 and 2 per cent. respectively. Diagrams are given showing how the alternating motor and the continuous current motor may be comprised in one single machine. E. K. S.

394. *Electric Traction Problems.* **J. Fekl.** (Zeitschr. Elektrotechn., Wien. 17. pp. 435–440, August 13, and p. 464, September 3, 1899.)—The author shows how, by using the mechanical characteristic of the motor, to calculate the current taken by the motors for a given load and gradient, the speed of the car, the ampere hours per motor and car mile respectively, the mean total current and power, and the mean drop along the line. A. H.

395. *Multiple Unit System for Electric Railways.* **F. J. Sprague.** (Amer. Instit. Elect Engin., Trans. 16. pp. 211–249. Discussion, pp. 249–268, 1899.)—A paper descriptive of the multiple unit system of electric traction (see 1898, No. 344) as applied to the South Side Elevated Railway of Chicago. Each unit or coach of the train is equipped with its own motors and controllers, the latter being actuated by means of small pilot motors which are in turn controlled by the driver in the leading coach.

Some of the advantages of the arrangement are : —

The motor equipment is directly proportional to the number of car units.

Each car being lighted, heated, and braked independently it has independent movement in yards, car houses, or on the tracks.

Cars can be added to or taken from a train in about a third of the time that is possible with a locomotive system.

The fullest use can be made of sidings and tracks for storage and inspection.

The hammering of rail joints, &c., is diminished because of the less weight per driving wheel.

Increasing the number of motors on the train gives more room for increase of dimensions of essential working parts, such as bearings, gears, and commutators of any one motor ; also greater space for the application of brakes—electric and mechanical.

When the total motor capacity, say 600 H.P., is concentrated on one car of a six-car train, there is not the same ratio of weight on the drivers, and consequently a much smaller effective pull than with many smaller motors distributed over all the six cars of the train.

The discussion took the form of a series of questions, to each of which the author very ably replied. In replying to the suggestion that the controlling mechanism was intricate, the author stated that experience showed very little liability of the small pilot motors to get out of order. He pointed out that the cost of plant per H.P. in the generating station is about ten times what it is for the train equipment. It is therefore economical to expend money on the motors, controllers, &c., if by so doing the total H.P. of the generating plant can be reduced.

In referring to the chloride accumulator battery which has been installed on the South Side Elevated Railway, the author said he was an advocate of the storage battery for regulation and taking the peak loads, if it was put in under proper guarantees. (See also 1898, Abstract No. 344, and 1899, No. 1810.) E. K. S

396. *Surface Contact Traction Systems.* **G. Claude.** (Ind. Élect. 8. pp 338–342, August 10, 1899.)—The author discusses the underground conduit and surface contact systems. The following systems are criticised : Ayrton and Perry (1883), Pollak (1887), Lineff (1888), Diatto (1894), Thompson and Walker (1898). These systems are all based on that suggested by Ayrton and Perry in 1883, in which a powerful electromagnet is fixed on *each car,* and permanently excited from a battery of accumulators. Each

section is provided with a stationary magnetic device which, when the car is passing, is attracted by the electromagnet and causes contact to be made with the supply cable. The following systems are also discussed: Claret Vuillenmier, Hopkinson (1882), Wynne (1887), "The Safety Third Rail System," and Potter (1896). L. J. S.

397. *Effect of Temperature on Pull of Trolley Wires.* **M. Eisig.** (Elektrotechn. Ztschr. 20. pp. 653–655, September 14, 1899.)—A formula is given by which the differences of pull on trolley wires due to varying temperatures may be calculated. Assuming the usual practice of a span of 40 metres, area of trolley wire 50 square mm. (equal to 0·316 inch diameter), and a working tension of, say, 400 kilogrammes, the extra pull per degree Centigrade is about as follows:—

From	0° to—10°	Centigrade	8 kilogrammes.
"	—10° to—20°	"	9 "

From	0 to+ 8°	Centigrade	7 kilogrammes.
"	+ 8 to+12°	"	6 "
"	+12 to+20°	"	5 "
"	+20 to+26°	"	4 "
"	+26 to+30°	"	3 "

Twelve kilogrammes per square mm., or a total of 600 kilogrammes for a 50 square mm. wire, is within the safe elastic limit. E. K. S.

398. *Bede Contact System.* **A. Witz.** (Écl. Électr. 21. pp. 201–207, November 11, 1899.)—At present, 82 per cent. of the existing electric tramways are on the overhead system, 7 per cent. on underground conduit, and 11 per cent. on accumulator systems. The Bede system consists essentially of a plough travelling in a slot outside one rail and mechanically pressing horizontally outwards contact pins which pass through rubber glands, and which when pushed back make direct contact with a bared portion of the feeder cable. Details of construction are given. Since the beginning of 1899, 405 metres of the Brussels Tramways Co.'s lines have been working satisfactorily on this system in all kinds of weather. E. H. C.-H.

399. *Electromagnetic Brakes.* **M. Schiemann.** (Elektrotechn. Ztschr. 20. pp. 535–539. Discussion, p. 539, July 27, 1899. Paper read before the Elektrotechnischen Vereins, Berlin, May 30, 1899.)—The conditions to be fulfilled by a good brake for electric cars are enumerated. Rim and axle brakes are useful until the wheels slip on the rails, when some form of rail brake must be resorted to. Electric braking by short circuiting the motors is undesirable, as the kinetic energy of the car is spent in heating the motor. This may be avoided by using a magnetic brake consisting of an iron disc keyed on the axle and acted on by a crown of electromagnets on one side. Braking takes place owing to the eddy currents in the disc and by friction of the disc on the pole faces as the attraction increases. The electromagnets are excited either from the car motor or from the line. A hand brake must be employed to bring the car finally to rest. For more powerful braking than can be applied through the adhesion of the wheels, a magnetic rail brake is described, consisting of a bar suspended longitudinally between the wheels and a few inches above the rail. This bar carries a brake shoe at

each end, and a number of pole shoes along its length, which when excited are attracted on to the rail, thus forcing the brake shoe under the front of the trailing wheel, effectually bringing the car to rest on emergency or allowing it to run at reduced speeds as required. Experiments with this form of brake fitted to a trailer car on the Dresden tramways are described. A discussion followed, in which **Hefner-Alteneck** and **Klose** pointed out the reduction of the coefficient of friction at high speeds and the corresponding advantage of magnetic brakes acting by means of Foucault currents. L. B.

400. *Fall of Potential along Rail Return.* **A. Barbillion.** (Écl. Électr. 21. pp. 94–96, October 21, 1899.)—At every point of a rail conveying a current part of the current strays into the surrounding soil. Let the potential of the rail at the point $x = 0$ be V_0, and its potential at the point $x = l$ be V_1. Let, further, ρ stand for the contact resistance, per unit length of rail, between the rail and earth. The author shows that the potential V at any point x may be represented by the equation—

$$V = Ae^{x/\sqrt{\rho}} + Be^{-x/\sqrt{\rho}}$$

where A and B are two constants defined by the equations—

$$A + B = V_0$$
$$Ae^{l/\sqrt{\rho}} + Be^{-l/\sqrt{\rho}} = V_1.$$

A. H.

401. *Experiments on Rail Bonds.* **H. H. Norris.** (Street Rly. Rev. 9. pp. 582–583, September 15, 1899.)—The author deals briefly with earth resistance, and points out that this is, as a rule, sufficiently high, so that it should not be possible for any great quantity of the return current to leave the rails unless the bonds are defective. The requisites of a good bond are both mechanical and electrical. They must not be able to work loose, and they must be flexible to allow for the yield of the rails to the weight of a car, and also to allow for changes in length of rails due to temperature. The electrical conductivity must be good, with large connecting surfaces at the rails, a sufficiently high pressure between those surfaces, and no chance of oxidation of those surfaces.

A summary of tests made by Little and Reynolds is given. The method used was to take two voltmeter readings for each bond test, one between two points on the rail about 15 feet apart—being proportional to current in rail—and the other across the rail joint itself. From the results it was found that in some cases the joint resistance was less than one-third the actual bond resistance, and in other cases was more than ten times that value. The author states that these tests could best be performed by pushing the contacts rapidly along the line, a kick of the voltmeter pointer indicating the presence of a bad bond. The difficulties are: (1) to operate the device fast enough to work in with a regular schedule, (2) to make a proper note of the faulty joints, and (3) to operate with few observers.

He suggests using a recording voltmeter, the drum to be driven from a wheel running over the rail. This may be done by having a small platform suspended behind an ordinary car, having a flanged wheel running on the track to drive the voltmeter drum, and carrying at its ends the spring contacts to rest on the rail. The drum of the voltmeter may have a spiral travel, and thus a continuous and permanent record of the state of the line would be *obtained.* E. D.

402. *Accumulator Traction.* **J. Zacharias.** (Elektrotechn. Ztschr. 20. pp. 471–472, July 6, 1899.)—The paper contains some details regarding the Ghent electric tramcars, which are driven entirely by accumulators. Each car contains 12 boxes of 9 cells each, making up a total of 108 cells, the weight of which is about 2,000 kg. The capacity of the cells is sufficient for a 50–58 km. run. The normal speed in the town is 12 km., and in the suburbs up to 30 km. per hour. The charging of the cells is effected as follows: The initial charging current is 60–80 amperes, at a P.D. of 250 volts. When the current falls to 45 amperes, the P.D. is, by means of boosters, raised to 275 volts, the current rising to about 50 amperes. The charge is then continued until the current falls to 10 amperes. This method of charging is found to give the most economical results. The cells are of the Julien type, with corrugated Planté positives and negatives consisting of perforated lead cylinders packed with spongy lead. A capacity test by the author of a cell weighing 25 kg. (including acid) gave 300 ampere hours at a 15-ampere, and 250 ampere hours at a 50-ampere discharge rate. The author states that cells which had run 8,000 kilometres showed no signs of deterioration. A. H.

403. *Accumulator Trials.* **A. Bainville.** (Électricien, 18. pp. 249–253, October 14, 1899.)—Methods and results of the Automobile Club trials. Out of the large number of competitors, only four batteries had had no failure in voltage up to August 26, 1898 (*cf.* Électricien first half-year, 1899, p. 385 and 18, pp. 49 and 161). M. O'G.

404. *Weight of Accumulators for Electric Vehicles.* **J. Rosset.** (Ind. Élect. 8. pp. 386–388, September 10, 1899.)—By a series of calculations the writer of this article endeavours to determine the weights of accumulators which are necessary for an electric vehicle to accomplish a given distance. He gives an equation—

$$y = \frac{Pl}{250 - l}$$

where y represents the weight of the necessary accumulators.

P represents the weight of the vehicle with its complement of passengers.

l represents the distance travelled in kilometres.

Assuming a vehicle and passengers to weigh, say, 1,000 kilogrammes, he arrives at the following results:—

l kilometres travelled	10	20	30	40	50	60	70	80	90	100
y kilogrammes of accumulators ...	41	86	136	190	250	315	388	470	562	666

Curves are given showing the necessity (from the point of view of efficiency) of having charging stations at frequent intervals.

A case is considered of an electric vehicle going from point A to B in a given time, the distance A B being the direct route but badly paved, with a coefficient of traction of, say, 0·04. A second route, ACB, is one and a half times as long but the road is good, the coefficient of traction not exceeding 0·02. Instead of taking the direct route at, say, 8 kilometres an hour, it is therefore better to travel along ACB at 12 kilometres per hour, as the coefficient of traction increases only very slightly with the speed, and consequence less energy is required on the longer track.

The conclusion is drawn that in the design of electrically propelled vehicles it is as important to reduce the losses in the motors, gearing, &c., as it is to reduce the weight of the cells. E. K. S.

405. *Siemens and Halske Electric Omnibus.* **Siebert.** (Elektrotechn. Ztschr. 20. pp. 671–674, September 21, 1899.)—An illustrated description of an electric omnibus to carry 16 passengers. The omnibus is fitted with four motors, each giving 4 H.P. with 350 volts when running at 550 revolutions per minute. Hagen accumulators are used, there being 200 cells weighing 1,500 kilogrammes. The total weight of the omnibus complete is 6,500 kilogrammes. Particulars of a test made on April 21 (1899) are given. E. K. S.

406. *Electric Waggon.* **M. Schiemann.** (Deutsche Zeitschr. Elektrotechn. 6. pp. 104–107, July 1, 1899.)—Description of an electric waggon propelled by accumulators. The motor, by Kummer and Co., gives 8 H.P. at 80 volts and 1,500 revolutions, at which speed the waggon travels on the level at 7 kilometres per hour. The weight of the complete waggon, inclusive of the accumulators, is 4,227 kilogrammes, the battery alone weighing 1,400 kilogrammes. The number of the cells is 44, so that they can be charged from any 100 or 110 volt circuit. Some particulars of the power taken when travelling over different kinds of road surface are given. E. K. S.

407. *Signalling on Tramways.* (Elect. Engin. 24. pp. 454–455, October 13, 1899.)—Owing to numerous curves at Dover, much delay used to be caused by cars waiting for one another unnecessarily at turn-outs. Signalling pillars were therefore erected at suitable points. When the car passes a pillar, the conductor presses a switch which sets at "danger" or "line clear" the signal arm in that pillar as well as in the next pillar in front or behind. The arms are moved by a polarised armature between electromagnets. Since signalling was adopted, each car is enabled to make two complete trips a day more than before, *i.e.*, an extra profit of £1 per car per week. The financial results of the Dover tramways for the year ending March, 1899, are given. The expenses per car mile were 9·06d., and the receipts 10·92d. The energy used amounted to 0·98 units per car mile.

E. H. C.-H.

408. *Signalling-System for Tram-Cars.* **H. B. Rogers.** (Street Rly. Rev. 9. pp. 387–388, June 15, 1899.)—The system comprises rail contacts, signal boxes, signal lamps, and semaphores for street railways. The principal feature of the system is the rail contact-box. A steel tongue, or spring, is pivoted at one end to the web of the rail; the free end carries a plunger which works in one arm of a U-tube containing mercury. When the plunger descends under the weight of a passing car, the mercury in the second arm of the U-tube rises and makes contact with a metallic point connected to the semaphore apparatus. In frosty weather the space under the plunger was filled with salt; they were never frozen. No trouble from rain-water was experienced; the mercury made an effective water-tight joint. R. A

409. *Magnetic System of Railway Signalling.* **W. S. Boult.** (Elect. Re 45. pp. 491–494, September 22nd, 536–537, September 29th, and 578–57 October 6th, 1899. A paper read before the British Association.)—The defec of the present syste of semaphore, lamp, and detonator signalling are di cussed and the req ments of a perfect system enumerated. All visu

systems are undesirable, owing to the necessity of signalling in three ways—one for daytime, one for night-time, and a third for fog. Mechanical or electrical methods are liable to damage.

The only method of meeting the requirements at all satisfactorily is by means of electromagnetic signals. The details of such a system are figured and described. The signals are transmitted from electromagnets lying between the rails to a pivoted polarised needle carried below the engine, which closes one of two relay circuits. Thus two signals can be given instead of one as in the present system. The signals are recorded by a small indicator instrument in the locomotive cab having two small semaphore arms on the face. The relay is operated by either of two batteries. A defect in either battery circuit is immediately indicated by a coloured spot on the indicator face, and signalling continues by means of the other battery. At a junction the line open is indicated by numbers on the indicator face. Arrangements can be made for telling the driver which of eleven alternative lines is offered. Just before reaching a signalling point a set of permanent magnets put the semaphores to danger. When home or distant dangèr signals are passed different bells are thrown into circuit, which continue ringing until stopped by the driver employing a special "relay push." By automatic switching the current is allowed to flow only while a train is on the block. The method is also adapted to an automatic block system. As to costs, the author estimates that the upkeep per annum would not exceed the extra expenses incurred on one line in "fogging" alone during five days of fog in 1888, viz., 58s. per post. Reliability of action has been tested by fitting a Great Northern Railway express engine with an early form of the apparatus, by which signals were taken perfectly at a speed of 70 miles per hour. A discussion followed. L. B.

410. *Automatic Block System.* (Elektrotechn. Ztschr. 20. pp. 581–582, July 1899.)—The Austrian State Railway has recently introduced a modified form of the Siemens' automatic block-system for the Waidhofen-Oberland and Reifling-Selzthal lines. It is intended to operate so as to ensure safety of the trains both on the section immediately in front and the section immediately behind a particular train. A diagram is given, showing the electrical connections and the general arrangement of switches. R. A.

411. *Wind Power Electric Lighting System.* E. Dick. (Zeitschr. Elektrotechn., Wien. 17. pp. 403–407, July 23, and 423–426, July 30, 1899.) This is a description of the details of a system installed by Wuste and Rupprecht, of Vienna, for a private electric lighting plant driven by wind power, with the necessary storage and switching arrangements. The windmill itself is not described. The plant is designed for a wind velocity of 9 to 18 miles per hour. Owing to the unreliability of the driving power, two batteries are installed, each capable of supplying one evening's load. The switching and regulating gear is almost entirely automatic. The voltage is regulated at 90, and the dynamo switched out of circuit as soon as it falls below this. The batteries and switching apparatus are installed in the house to be lighted, the dynamo in the most suitable spot for driving. In the daytime the batteries are charged in parallel, and each is automatically switched out of circuit when the voltage of each cell rises to 2·5 volts. At night one of the batteries is connected in parallel with the dynamo to the lamp circuit to regulate the voltage, the other being connected to take any surplus power as a charging current. The next night the functions of the

two batteries are reversed. This reversal, which is the only non-automatic part of the switching gear, is carried out by the same switch which puts the lamps in and out of circuit. When the wind falls both batteries are paralleled on the lighting circuit. The change from charge to discharge is made by putting small resistances in series with the battery. There is no end cell regulation. Fully illustrated details are given of the necessary apparatus, and a mathematical explanation of the method of automatic operation. L. B.

412. *Electric Train Lighting.* **Auvert.** (Écl. Électr. 20. pp. 460–465, September 23, 1899. Abstract of an article in the Revue Générale des Chemins de Fer, 22. p. 57, August, 1899. Also Zeitschr. Elektrotechn., Wien. 17. pp. 587–589, November 19, 1899.)—The various systems hitherto employed for train lighting by electricity are noticed. The author then describes a new system which is being employed experimentally by the Cie. P.L.M. of France. It resembles the Stone system in having a dynamo and battery on each car, but the method of regulation is unique. The dynamo is driven by a friction wheel from the inside face of a carriage wheel, and its speed varies with that of the train. It is excited by a constant current from the battery, which also feeds the lamps when the speed is too slow. As the speed rises an automatic switch throws the dynamo into parallel with the battery. A commutating device changes over the dynamo connections if the direction of the train's motion be reversed. The current in the main circuit is regulated to a constant maximum value by being passed through a small series wound motor, whose spindle carries a brake pulley and brake whose pressure can be adjusted. If the dynamo current rises above a certain maximum value the motor overcomes the resistance of the brake and rotates, introducing the necessary back E.M.F. to keep the current constant. This maximum current is sufficient to feed the lights and charge the battery. As the speed falls the charging current first falls, then becomes a discharge, and at a lower speed still the dynamo is automatically cut out and the whole current supplied from the battery. The lamps can be "turned down" by putting two in series, a compensating resistance being put in parallel to keep the load steady. The carriage is lit by thirteen 9-c.p. lamps taking 1·22 amperes each at 15 volts, 16 amperes in all. The regulating motor brake is adjusted to give a constant maximum current of 28 amperes, the remaining 12 going to charge the battery, which has a capacity of 180 ampere hours. It consists of eight cells, weighing in all 460 lbs., and is able to supply the lights without the aid of the dynamo for eight or nine hours. The experimental carriage has been in constant service since March, 1899, having completed 18,000 miles satisfactorily. In a complete train only one dynamo in the brake van need be employed, with a battery and switching gear on each carriage. L. B.

413. *Electric Train Lighting.* (Engineer, 88. pp. 46–47, July 14, 1899.)—The latest design of the Stone system is described, as used on the Metropolitan Railway. Blinking of the lamps when the automatic switch cuts out the dynamo is avoided by feeding the lamps through a resistance when running and cutting this out when the train comes to a standstill, thus compensating for the lowered pressure of the battery. Other improvements are explained, with illustrations. (See also 1899, Abstract No. 390.) A. H. A.

414. *Arc Lamps.* **H. Görges** and **Queisser.** (Elektrotechn. Ztschr. 20. *pp. 444–449, June* 22, 1899. Paper read before the Elektrotechn. Verein,

Berlin.)—The advantages of differential over shunt regulated arc lamps are pointed out. Characteristic curves for each type of lamp are given, showing the effects of variations of the terminal voltage and the sensibility of the regulating mechanism. These variations are also worked out mathematically, and the differential coefficients are obtained for the current consumed and the light emitted with respect to the other variables. These show much smaller values for the differential than for the shunt lamp.

The new differential focussing arc lamp of Siemens and Halske (German patent 101050, 1898) is fully described, as well as the methods of adapting it to various conditions of service. With good lamps and a steady voltage, three lamps can be run in series between the 110 volt constant potential mains. Complete tests are given of 9 ampere lamps running two in series with 46 volts across the lamp terminals, and three in series with 35 volts. The watts consumed in the lamps per mean spherical candle-power are 0·59 and 0·66 in the two cases respectively in favour of the higher voltage lamp. But the power that has to be dissipated in resistance in the former case balances this difference in efficiency, and causes the total light obtained to be practically the same, viz., 1,400 c.p. A discussion followed. (See also 1899, Abstract No. 1823.) L. B.

415. *Enclosed Arc Lamps.* **W. A. Turbayne.** (Canad. Elect. News, 9. pp. 159–160, July, 1899.)—In this article the theory and practice of the working of enclosed arc lamps are clearly explained, and the running cost compared with that of open arc lamps. A. H. A.

416. *Theatre Lighting.* (*Covent Garden.*) (Elect. Engin. 23. pp. 558–564, 1899.)—Lamps of white, blue, red, and amber glass are carried in battens of oak and iron, 40 feet long, arranged vertically and horizontally; the oak is grooved to carry the cables, and is supported on steel lattice-work. Special boxes are made for connecting the cables and for switching on the wing lights. In an elaborate switch-room control is given by means of liquid regulating resistances. Diagrams of float, battens, and hand-wheel controllers are given. M. O'G.

417. *Incandescent Lamp and Transformer Construction in America.* **H. E. P. Cottrell.** (Engineer, 88. pp. 364–366, October 13, and pp. 387–388, October 20, 1899.)—The author remarks that comparatively few of the ever-increasing number of incandescent lamps manufactured attain the standard of even moderate efficiency, and fewer still approach the ideal where the "curve of candle-power" could be represented by two parallel horizontal lines throughout the whole life of the lamp.

Definitions and curves are given of "specific efficiency" and "total luminous efficiency" of incandescent lamps. It is pointed out that the lamp which maintains throughout its life the highest average interval between the candle-power and watts per candle curve, is the most effective for lighting purposes, so that the average specific efficiency, and not the length of life, is what should be principally considered in selecting a lamp.

Life alone, apart from candle-power and efficiency, is of small importance, and at the present low price of lamps even doubling the number of lamp renewals will add only a small percentage to the general cost of lighting, while it is possible, by the judicious choice of lamps, to increase the lighting efficiency by as much as 40 or 50 per cent. With regard to the effective illumination or "candleage" of a lamp, as this varies considerably in different

directions, it should be determined while they are rapidly revolved and their rating made to accurately correspond with the actual average illumination of the whole horizontal plane and not with one or more selected points in that plane. The factors which determine the "candleage" of a lamp are (1) the quality and shape of the filaments; (2) the character of the vacuum; (3) the quality of the glass; and (4) the regulation of the pressure at which it is kept lighted.

There is very little difference in the system of looping in the various makes of incandescent lamps, or in the materials of which the filaments are composed, or in the process of carbonisation. There is also but little difference in the dimensions given to the filaments, so that, approximately, filaments of equal capacity of different makes should possess equal illuminating powers if the quality of their surfaces is uniform.

The character of the vacuum surrounding the filaments is almost as important as the quality of the filaments themselves in determining the candleage of a lamp, more especially in high-voltage lamps. The character of the glass of which the bulbs are made affects the candleage of a lamp to a very serious extent, the best glass intercepts as much as 10 per cent. of the illuminating power, and inferior glass double that amount, even when perfectly clear and colourless.

A table is given of the standard dimensions of some of the best proportioned bulbs for various purposes and uses, which are made from Corning glass, which does not intercept more than 6 or 8 per cent. of the total photometric radiance.

The wattage of small high-voltage lamps per candle is not so low as that of lamps of lower voltages, and their specific efficiency not so good; whereas a 16-candle 110 volt lamp will consume about 3·1 watts per candle, a similar lamp for 220 volts will consume 3·8 watts per candle-power, the specific efficiency of the first being 0·323, and of the second only 0·263, and the length of life is also proportionately shorter.

Transformers.—The efficiency of transformers depends on the perfection and arrangement of the following details of their construction: (1) Insulation. (2) Mechanical protection. (3) Regulation. (4) Character of core metal and consequent amount of hysteresis. (5) Arrangement of coils and consequent amount of impedance.

There are two distinct types of transformers in use. The "shell" type which is the more recent of the two, is said to be cheaper to manufacture. It however, possesses inherent disadvantages, the chief ones being weak insulation and increased impedance arising from the overheating of the coils due to their being buried in the iron, together with increased hysteresis owing to the iron being relatively cooled. The other type is known as the "core" type and is being more and more adopted in all recent installations.

The author advocates that the insulation between the primary and secondary of the transformer should be subjected to a disruptive test in the factory of at least 10,000 volts, the transformer itself being subjected momentarily to double, treble, or even quadruple the working pressure.

In order that the insulation of the transformer should last, the coi should be firmly fixed to the cores and the latter to the cases, so that the relative position cannot alter. With regard to core losses, the only practic way of avoiding initial hysteresis and its progressive increase, through the s called "ageing of the iron," amounting in some cases to 50 per cent. and 1 per cent. of the original core loss after a few months' use, is to ensure u formity of texture in the cores uilding them up of thin discs of carefu

selected metal, these discs being insulated by japanning and joined by strips —three, four, or five in number—along the edges. The width of the gap between the discs is shown by experiment to have no effect upon the efficiency of the cores made from them, and in practice the discs are pressed together as close as possible, so that the gaps composed of japanning are reduced to a minimum thickness. In cores constructed in this way the initial hysteresis is very small, and there is practically no sensible ageing.

Diagrams are given showing the connections to be employed in transformer testing.

The principles governing transformer use in modern stations can be briefly summarised as follows :—

(1) The station voltage should be regulated so that all lamp circuits at the average load can be run at normal pressure. (2) All transformers should be connected with secondary mains serving districts of a maximum area. (3) All transformers should be subjected to periodical and frequent tests, independent of guarantee or reputed performance. (4) The hours of load on each transformer should be increased to a maximum. (5) The total transformer capacity required to carry a given total station load should be reduced to a minimum. (6) Transformer regulation at a frequency of 60 periods should be maintained within limits of 2½ per cent. and defects from this cause at average loads should not exceed 1 to 1½ per cent., the percentage of increase with higher frequencies being maintained as low as possible. (7) Core losses at 60 frequency should not exceed 2 per cent. for 2,000 watts capacity, 1½ for 5,000 watts, and 1 for 15,000, and so on, the proportion of loss diminishing with higher frequencies. L. J. S.

418. *Berrenberg Lamp Factory.* (Electrician, 44. pp. 35–38, November 3, 1899.)—The chief feature of the Berrenberg lamp is that the vacuum is produced by a mechanical pump in which all joints, valves, &c., are enclosed in a vacuum jacket which is maintained by a second pump producing a rough vacuum. It is claimed that the absence of mercury vapour in the lamp prevents the blackening of the bulb after use. This paper gives a description, with illustrations, of the works recently erected by the Berrenberg Electric Lamp Syndicate. The works are capable of turning out 40,000 lamps per week. The paper also gives two diagrams of curves which show that the candle-power of a 16-c.p. lamp falls to 13 c.p. at the end of 1,000 hours, while the watts per c.p. rise from 2·4 to 3·0 in the same time. E. C. R.

419. *Electric and Gas Lamps.* **S. A. Rumi.** (Rivista Sci. Industriale, 31 pp. 139–143, June 30, 1899. From the "Giornale Scientifico" di Palmero No. 4, 1899.)—The author compares the electric incandescent lamp with the Auer (incandescent) gas lamp. In point of economy in illumination the latter is superior, but the life of a gas mantle is considerably less than that of an electric incandescent lamp. Figures are given showing the percentage loss of candle-power of two English and three German mantles, after burning 100 and 500 hours; the means of these are respectively 15 per cent. and 45 per cent. Voelher found a loss of 50 per cent. in the light of two English mantles after 250 hours. Massa, the inspector of the street lighting in Genoa, finds that the life of different mantles of the same type is exceedingly variable.

For the loss of light in electric lamps the author gives 20 per cent. after 800 hours as a practical figure, taking perfect and faulty lamps together.

G. H. B

REFERENCES.

420. *Development of Electric Stations.* **A. D. Adams.** (Cassier, 17. pp. 91–103, December, 1899.)—The author deals in general terms with the development of electricity supply stations from their commencement up to the present day. The advantages gained by modern introductions are pointed out, examples of present-day stations and several illustrations of typical generating works and substations are given. E. D. P.

421. *Single-Phase Distribution.* **H. A. Wagner.** (Elect. Rev. N.Y. 34. p. 343, 1899. Abstract of a paper read before the National Electric Light Association, New York, May 24, 1899.)—This is an introductory article on the relative merits of the single-phase and three-phase alternating currents for combined distribution of light and power. W. G. R.

422. *Generators and Polyphase Plant of Chicago Edison Company.* **H. E. Niesz.** (Amer. Electn. 11. pp. 445–451, October, 1899.)—A fully illustrated and lengthy article dealing, in detail, with the direct-current, three-phase generators, and the regulating apparatus, &c., connected therewith, of the Chicago Edison Company. E. D. P.

423. *An 83-mile Electric Power Transmission Plant.* **J. A. Lighthipe.** (Cassier, 17. pp. 3–13, November, 1899.)—Illustrated description of the Southern California Power Company's power stations and transmission line to Los Angeles (See 1899, Abstract No. 923.)

424. *Electric Traction Data.* **H. J. Ryan.** (Street Rly. Rev. 9. pp. 580–582, September 15, 1899.)—Data of equipment and working of eight street railway plants.

425. *Financial Data of Traction Systems.* **E. E. Higgins.** (Street Rly. Journ. 15. pp. 680–684, October, 1899.)—The systems referred to are in various parts of the world.

426. *Accumulators for Electromobiles.* **(E. C. Rimington.** (Automotor Journal, 3. pp. 493–494, July; pp. 598–600, September; 4. pp. 18–19, October; and pp. 61–63, November, 1899.)

427. *Control of Electric Vehicles.* **E. H. Cozens-Hardy.** (Automotor Journal, 3. pp. 495–496, July; pp. 608–609, September; and 4. p. 32, October, 1899.)

428. *Electric Railway and Tramway Carriage Works, Limited, Preston.* **B. Sykes.** (Elect. Engin. 24. pp. 587–591, November 10, 1899.)

429. *Train Service and its Practical Application.* **I. A. McCormack.** (Street Rly. Journ. 15. pp. 790–795, November, 1899.)—Paper read before the American Street Railway Association at Chicago.

430. *Car Mileage.* **H. C. Mackay.** (Street. Rly. Journ 15. pp. 797–799, November, 1899.—Paper read before the American Street Railway Association at New York.)—Discussion of suitable units for comparison of traction systems.

431. *Care of Car Equipment.* **J. H. V. Veer.** (Street Rly. Journ. 15. pp. 796–797, November, 1899.)—Read before the Amer. St. Railway Association.

432. *Construction and Maintenance of Steel Railway Tracks.* **E. Butts.** (Street Rly. Journ. 15. pp. 795–796, November, 1899. Paper read before the American Street Railway Association at Chicago.)—Opinions on track construction, and illustrations of Kansas City track. J. T. I.

TELEGRAPHY AND TELEPHONY.

433. *Pollak-Virag Machine Telegraph.* (Elect. World and Engineer, 34, pp. 84–85, July 15, 1899.)—The merit of the system is its high speed. The messages are perforated on a strip of paper which passes under two small brushes connected to the reverse poles of two separate batteries. The paper slip is moved along by means of a cylinder which is connected to the circuit and makes contact with the brushes above it whenever there is a hole in the paper strip. In this way positive or negative currents will be sent over the line according to which one of the brushes comes in contact with the cylinder. The paper strip has two rows of perforations, the one serving for the positive

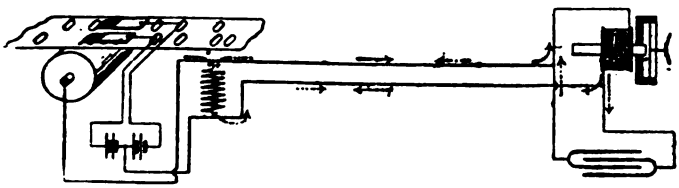


DIAGRAM OF CIRCUITS.

current impulses, the other for the negative ones. The one impulse produces at the receiving station a line going upward corresponding to the dash in the Morse code, while the other impulse produces downward strokes, corresponding to the dots in the Morse code. The receiving apparatus is a telephone disc provided with an oscillating mirror which makes a photographic record of its motion on a revolving cylinder. The period of the forced oscillations is made to coincide with the natural vibration of the mirror by means of a condenser, and an inductance is mounted in parallel with the transmitting apparatus to balance that of the telegraph circuit. As many as 100,000 words have been transmitted per hour with a working pressure of 25 volts. E. E. F.

434. *Simultaneous Telegraphy and Telephony.* **H. S. Webb.** (Amer. Electn. 11. pp. 420–423, September, 1899.)—The reason why an inductance and capacity retard the rise and fall of the dot-and-dash current is given. To prevent a Morse current affecting a telephone, it is connected in series with a condenser which intercepts continuous currents, but not the alternating current for the telephone. To ensure telephone currents reaching the receiver and not going to ground through the telegraph, a 500-ohm inductance coil is put in series with the telegraph relay. An illustrated description of the method of construction of the coil and condenser is given. M. O'G.

435. *Compensating Condensers in Telegraph Circuits.* **M. G. Simpson.** (Electrician, 43. pp. 685–686, August 25, 1899.)—By equating the instantaneous values of the currents a short time after interrupting the circuits of a condenser and an inductive resistance, the capacity of the condenser required by any given relay having self-induction is calculated. This is modified in the case of an actual line by the preponderance of its capacity. A practical case is worked out. M. O'G.

436. *Resistance of Earth Plates.* ***R. Nowotny.*** (Zeitschr. Elektrotechn., Wien. 17. pp. 445–446, August 20, 1899.)—The results of tests of the resistan

of various earth connections by Wiechert's method, carried out by the German Telegraph Department, are given, and the effect of the material of the subsidiary earth plate employed on the results is discussed. L. B.

437. *Wireless Telegraphy.* **J. L. Adams, Jr.** (Elect. World and Engineer, 34. pp. 273–274, August 19, 1899.)—Further experiments on self-inductance in a receiving circuit with coherer. Three or four 8 c.p. 104 volt lamps in series with a coherer have the same effect on the latter as an inductive resistance of 5,000 ohms, *i.e.*, they stop all action in the coherer. A touch from the positive wire of a 200 volt direct current circuit causes a coherer to respond instantly. Horizontal slits were found to cut off all effects from vertical antennæ. M. O'G.

438. *Storage Battery in Telephone Exchanges.* (Elect. World and Engineer, 34. pp. 377–378, September 9, 1899.)—The Bell Exchange at Philadelphia employs two 80 kw. dynamos, and the four-volt, eight-volt, and twenty-volt batteries are charged by motor generators. The twenty-volt battery, with 1,000 ampere hours' capacity, furnishes all current for subscribers talking and calling up the office. The subscriber, by unhooking his telephone, operates a relay which works a four-volt lamp; the lamp is extinguished as soon as the operator plugs into the jack. The cord with which the operator connects the calling subscriber to his listener is wired to the twenty-volt battery. M. O G.

439. *Telephone Exchange Patents.* (Elect. World and Engineer, 34. pp. 378–379, September 9, 1899.) (See Science Abstracts, 1899, No. 1313.)—C. Scribner, in a patent dated August 29, 1899, uses polarised individual annunciators with a battery introduced in the connecting device, so that when two lines are connected the annunciator will not act. This inventor would dispense with spring-jack switches and avoid the use of test wires in multiple systems. In a second patent issued August 29, 1899, he shunts the annunciator and incidentally provides a new test system which uses a buzzer to detect whether an annunciator coil is or is not shunted and the line therefore in use. M. O'G.

440. *Automatic Telephone Exchange at Augusta, Ga.* **L. Campbell.** (Elect. World and Engineer, 34. pp. 301–302, August 26, 1899.)—An illustrated description of this automatic telephone exchange. A complete copper metallic circuit is used and storage batteries furnish energy to operate the machines, which are grouped on a central switchboard to the number of one thousand. One inspector and two assistants look after the whole system.

The method of calling any number is to turn a dial on the instrument; thus, for No. 687 the dial is first turned to 6, then to 8, and then to 7, and direct communication is then obtained with 687. If on turning the magnetic crank the subscriber's own bell does not ring the number wanted is engaged. Absolute privacy is claimed. M. O'G.

441. *Charleroi Installation.* **E. Piérard.** (Électricien, 18. pp. 129–1[illegible] August 26, 1899.)—Description of a central exchange for 1,200 subscriber[illegible] Overhead wires alone are used—the insulators on the turret are only 17 to [illegible] centimetres apart, yet no contacts occur—"Standard" boards are used. Th[illegible] indicators are reset automatically, and the current used for this purpose is c[illegible] off by the automatic action, thus effecting considerable economy. M. O'[illegible]

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

FEBRUARY 1900.

GENERAL PHYSICS.

442. *Determination of the Earth's Density and Gravitation Constant.* **A. Gerschun.** (Comptes Rendus, 129. pp. 1013–1015, Dec. 11, 1899.)—If a liquid be in equilibrium under the earth's attraction, and a heavy spherical mass is made to approach it, the surface of the liquid assumes a new form of equilibrium, which is a surface of revolution about the line joining the centre of the heavy sphere with that of the earth. Denoting by R the earth's radius, M its mass, r the radius of the heavy sphere, μ its mass, and h the distance of its centre from the free surface of the liquid, the author finds for the radius of the osculating sphere $\rho = \frac{Mh^2}{\mu R^3 + Mh^3}hR$, approximately, and thence derives the formula—

$$\frac{R}{\rho} = 1 + \frac{d}{\delta}a^3$$

in which d is the density of the heavy sphere, δ the density of the earth, and $a = r/h$.

If therefore a be constant, ρ is independent of the radius of the heavy sphere and depends only on its density. It thus enables the experimenter to use for the heavy sphere a small sphere of platinum.

The liquid is a bath of mercury. If ρ can be determined, δ, the earth's mean density, is thus known. The method used for determining ρ is the one employed by Foucault for the verification of plane optic surfaces. The details to be published in the Journal of the Russian Astronomical Society.

S. H. B.

43. *Action and Reaction.* **A. Broca.** (Comptes Rendus, 129. pp. 1016– Dec. 11, 1899.)—The writer refers to a memoir by Vaschy in which is n the existence of vector masses acting on a scalar pole in any field of Let X, Y, Z be the forces acting on the pole. Then these vector masses according to Vaschy, the forms—

$$M_x = \frac{1}{4\pi}\left(\frac{dZ}{dy} - \frac{dY}{dz}\right), \text{ \&c., where no potential exists,}$$

$$N_x = \frac{1}{4\pi}(nY_1 - mZ_1), \text{ \&c.,}$$

at a surface of discontinuity. Here l, m, n, are direction cosines of the surface. Broca shows that the vector masses (2) have no existence, and that (1) form "conservative" tubes notwithstanding the discontinuity, and therefore that their action on a scalar mass is analogous to the action of a magnetic shell. There is thus equality between action and reaction in this case.

The author refers to Maxwell's Theorem (p. 95 of his work) which he puts in the form that on a surface of discontinuity in the field of a vector only the component normal to the surface can be discontinuous, unless the force be infinite. From this he proves that the tube of force is "conservative."

He draws three corollaries: (1) That potential cannot be discontinuous—though there is what he calls a "couche de passage" of rapid variation in passing from one side of a surface to the other; (2) The electric current cannot be discontinuous; (3) All electric currents are closed, as Maxwell teaches. S. H. B.

444. *Standard Kilogramme.* **M. Thiesen.** (Abstract in Zeitschr. Instrumentenk. 19. pp. 312–317, Oct., 1899, from Trav. et Mém. du Bureau Intern. des Poids et Mesures, 8. 1893, and 9. 1899.)—The work of comparing the forty national standard kilogrammes with the international standards has now been finished. Instead of comparing all the national standards in every possible combination, they were divided into six groups of seven and seven groups of six, and all possible combinations were carried out within each group, thus diminishing the number of comparisons from 780 to 231. The standards, or "prototypes," were all made of an alloy of 90 per cent. platinum and 10 per cent. iridium. Their shape is that of a cylinder of height equal to its diameter. The density of each standard was determined by weighing in water. The comparison of each standard with the international standard was carried out by means of Runge's vacuum balance, provided with automatic changing device and a device for automatically centring the cylinder on the cross serving as a scale. The probable error in the mass of each standard is 0·002[illegible] mgr. when compared with the mean of all national standards, 0·0022 mgr. compared with the international standard, and 0·0028 mgr. compared with any other national standard. E. E. F

445. *Registration of Vertical Movements.* **N. Ach.** (Zeitschr. Instrumentenk. 19. pp. 309–312, Oct., 1899.)—The vertical motions of the centre of gravity of a ship at sea are recorded photographically by means of an aneroid barometer carrying a mirror instead of a pointer. The limit of accuracy of the records is about 1 m., which corresponds to an ordinate of about 2 mm. on the curve. Greater accuracy can be obtained by means of a micrometric eyepiece, but not in the photographic records. The apparatus is suspended by double Cardani suspension as used by Julius. E. E.

446. *Tachometer.* **R. A. Fessenden.** (Elect. World and Engineer, p. 739, Nov. 11, 1899.)—A description of what is practically an electrical h[illegible] tachometer. It consists of a disc commutator of six equal sectors, rotated [illegible] the shaft; three small brushes rest against this commutator, being arran[illegible] with angles of 90°, 90° and 180° between adjacent brushes. One brus[illegible] connected to a small storage battery, one to a condenser, and the other [illegible] specially damped Weston voltmeter, or a ballistic galvanometer. The [illegible] terminals of the battery, condenser, and voltmeter are coupled toge[illegible] The instrument may be standardised absolutely or by direct comparison [illegible] an ordinary speed indicator or counter. Any change in the voltage o[illegible]

battery is compensated for by the adjustment of a non-inductive resistance in series with the voltmeter.

The advantages are: (1) Readings may be taken at any distance from the rotating part; (2) A range of from 1 to 1500 is obtained, and its readings can be relied upon for accuracy to 1·5 of 1 per cent.; and (3) Extreme sensibility, the passing of the belt joint over the pulley or the change of speed of a loaded engine during its stroke being easily perceived.

It is also useful when used in conjunction with a synchronous motor for ascertaining the frequency of currents in alternate current mains. E. D. P.

447. *Physical Properties of Nickel Steel.* **W. H. Warren** and **S. H. Barraclough.** (Royal Soc. N.S. Wales, Journ. & Proc. 32. pp. 150–168, 1898.)—After reviewing previous work the authors give the results of tests made by themselves on specimens of Krupp's Mild (with 3 per cent. Ni), Medium-hard (8 per cent. Ni), and Non-rusting (25 per cent. Ni) Steel. Using round test-pieces 6 in. in length, with a cross-sectional area of 0·29 sq. in., and recording the results in the order above named (Mild, Medium-hard, and Non-rusting), the limits of elasticity of the specimens were respectively 19·2, 23·7 and 18·1 tons per sq. in., the yield points were 23, 36, and 23·7 tons per sq. in., and the breaking loads 32·9, 51·4, and 47·9 tons per sq. in.; the elongations after fracture were 22·3, 16·6 and 33·3 per cent., and the coefficients of elasticity in tons per sq. in. were 12,375, 12,110, and 11,760. Discs immersed in dilute sulphuric acid (1 of strong acid : 100 of water) at 170°–180° F. for 24 hours lost in weight as follows: Non-rusting = 0, Mild = 1·51 per cent. on 743 grains, and Medium-hard = 6·56 per cent. on 754 grains. A disc of Low Moor boiler-plate lost 5·06 per cent. on 731 grains under the same conditions. With the exception of the broad statements quoted above as to percentage of nickel, no information is given as to the composition of the samples. W. G. M.

448. *Alloys of Nickel and Iron.* **R. A. Hadfield.** (Instit. Civ. Engin., Proc. 138. pp. 1–125. Discussion, pp. 126–167, Oct., 1899.)—In this monograph the physical and mechanical properties of pure nickel and of practically carbonless alloys of iron with from 0 to 50 per cent. of nickel are given at length, and in an appendix an outline is given of the metallurgy of nickel. All samples were magnetic, the specimen containing 24·5 per cent. Ni being least so (it was only slightly attracted in bulk, though readily picked up when in small fragments), but even this was very magnetic when forged, whether before or after annealing. The author is of opinion that the alloys which gave abnormal magnetic tests in the hands of other experimenters (being non-magnetic when heated to 520° C. and remaining so after quenching) must have contained notable proportions of carbon. The tensile strength per sq. in. of iron increased slowly from 30 tons with no Ni, to about 49 tons in unannealed specimens (or 47 tons annealed) with 7·6 per cent. Ni; and then rapidly to about 94 tons (or 89 tons annealed) with 11·4 per cent. Ni; with higher percentages of nickel the tensile strength fell off. The 11·4 per cent. alloy also showed the highest elastic limit and resistance to compression, but at the same time gave evidence of low ductility. The paper concludes with an account of the uses of nickel steel for hydraulic cylinders, forgings, material for armour and its attack, guns, boiler-plates, and fire-box stays. In the discussion on the paper, **Barrett** gave the specific resistance in microhms per cc. of iron alloys containing from 0·14 to 0·19 per cent. C, 0·65 to 1·0 per cent. Mn, and 0·21 to 0·3 *per cent. Si, and* varying percentages of

nickel as follows: 1·9 per cent. Ni = 21·5; 3·8 per cent. Ni = 24·9; 11·4 per cent. Ni = 38·2; 19·6 per cent. Ni = 43; 24·5 per cent. = 55·5 microhms. A sixth alloy containing 31·4 per cent. Ni, but with 0·7 per cent. C. and 0·8 per cent. Mn, had a spec. res. of 86 microhms. All these tests were made with unannealed specimens, the resistance of the specimens after annealing was less by about 6 per cent. for the pieces containing comparatively little Ni, and 16 per cent. for the 31 per cent. alloy. With alloys containing much manganese the presence of a little Ni had no marked effect on the conductivity. Attention is specially directed to an alloy containing 25 per cent. Ni, 5 per cent. Mn, and 0·6 per cent. C, which had a spec. res. of 97·52 microhms per cc., and a temperature coefficient of 0·085 per 1° C. This is the highest spec. res. of any alloy known in commerce, being 60 times that of pure copper, and 4¼ times that of German silver. The alloy is described as being easily worked and a beautiful material. With regard to magnetic properties, a comparison is made between iron-nickel alloys and a good commercial iron, which gave a maximum induction of 17,480 in a field of 45 c.g.s. units, with a retentivity of 7,000 and coercive force of 1·66 measured in terms of H. The addition of a little Ni had but slight effect; the test with a sample containing 3·8 per cent. Ni gave (with same magnetic field) max. induct. = 17,480, retentivity but slightly increased, coercive force = 8·75. But the 11·4 per cent. alloy showed a drop to 8,560 (max. induct.), 4,800 (retentivity), and an increase in the coercive force to 17·15. The 19 per cent. alloy showed the highest coercive force of any alloy of steel yet examined. W. G. M.

449. *Propagation of Explosive Air Waves.* **P. Vieille.** (Comptes Rendus, 129. pp. 1228–1230, Dec. 26, 1899.)—Explosives are not necessary to produce waves of a velocity much higher than that of sound waves. When air is closed off by a collodion diaphragm at the end of a tube, and is compressed by a piston, the wave generated when the collodion bursts has a very high velocity. Some collodion diaphragms will burst at a pressure of 27 atmospheres, and the wave generated in them is propagated at a rate of more than 600 m. per second. The rate decreases by about 20 m. per second for every metre traversed, until it becomes the ordinary velocity of sound. E. E. F.

450. *Air-Resistance.* **G. H. Bryan.** (Nature, 61. pp. 107–109, Nov. 30, 1899.)—Deals with recent researches of Le Dantec and of Canovetti. As in 1893, Le Dantec makes the surface under test slide down a vertical wire. The start releases an electric recording device, and the current is broken when the body strikes the buffer at the end of its descent, which occupied 1, 2, or 3 seconds. The experiments were conducted in the nave of a chapel; it is necessary to avoid all disturbance of the air, even by persons moving. A surface, 1 m. square, moving with a velocity of 1 m. per second, experiences a resistance of 81 grammes; the form of the plate, circular, square, or triangular, is of importance—an observation made also by O. Mannesmann—and the resistance would appear to be proportional to the length of the contour. The law that, within certain limits, the resistance is proportional to the square of the velocity, is verified.

Canovetti suspends his bodies from a 3 mm. wire, 370 m. in length, stretched along the slope of a hill in the open air. As the wire hangs in a catenary, the body was arrested 90 m. before reaching the end of the wire. But the weight of the body affected the curve, and the time was measured simply by watching a chronometer. Yet the observations seem to be of practical value, as he finds a resistance of 90 gms. (instead of Le Dantec's

81 gms.). In most experiments he employed circular, not square, plates, and attached long or short cones to the rear of the plate (resistance reduced to 60 gms.), to both rear and front (resistance 15 gms.), or a hemispherical cap to the front (resistance 22·5 gms.), &c. He also tried bodies of the shape of a Chalais balloon, a long cone and a hemisphere joined by their bases, enveloped in a net; the resistance was 80 gms., and largely due to the net. H. B.

451. *Aeronautics and Soaring Machines.* **L. Hargrave.** (Royal Soc. N.S. Wales, Journ. and Proc. 32. pp. 55-65 and 209-222, 1898.)—These two papers deal with experiments on soaring carried out on models. The author differentiates between soaring and gliding. In the former a bird remains stationary, or it may be rises in a horizontal wind without flapping its wings, while in gliding the bird moves forward while slowly descending. Lilienthal's experiments were on gliding. The power which a bird has of soaring is attributed to the curved part of the wing nearest the body, there being a deep hollow on the under side of the wing, immediately behind the edge which first meets the wind. The air dividing on this edge, part goes over the wing and part under, and this latter part generates a vortex in the deep hollow on the under side of the wing, which vortex causes a greater pressure on the under side than there is on the upper side, and so gives the lifting power. The author considers the problem of the soaring bird as analogous to that of a ball retained in its position in front of a nozzle from which a high-pressure jet of water is issuing.

The models experimented with have curved surfaces representing the curved parts of the wings, and also other surfaces to represent the plane tips of the wings and the tail, which are requisite to give stability; these latter surfaces are like those on a cellular kite. One form of model has a long tube as base, the ends of the tube being loaded with lead. To each end of this tube, on the upper side, is attached a circular cylinder of tin plate, the axis being parallel to the tube. These two cylinders and the rod form a cellular kite. Between the two cylinders the curved surface is attached. It is made from sheet vulcanite, the sheet being three or four times as broad as it is long. A vertical section of the bent sheet is circular at the forward end, the tangent at the very end being vertical; then when the tangent comes nearly horizontal the form changes to the hyperbolic, and maintains that form to the other end. This curved surface can be angled bodily to the rod. Several other forms of model are described.

In the experiments, the models are tethered by a cord to a horizontal cord stretched between the tops of two high poles. The models then take up a position to windward of the tethering-point, sometimes on a level with it, and sometimes above it. J. B. H.

452. *Horizontal Pendulums.* **O. Hecker.** (Zeitschr. Instrumentenk. 19. pp. 261-269, Sept., 1899.)—A description of the construction of a horizontal pendulum apparatus, and an account of the comparison of the behaviour of two horizontal pendulums under the influence of various disturbances of the earth's crust. The pendulums were fixed beside each other on the same pillar, and their movements recorded on the same registration apparatus. The observations show that, with horizontal pendulums, comparable results can be obtained only when the pendulums are similar, have the same time of oscillation, and when, moreover, the same law of diminution of amplitude holds for both. J. J. S.

453. *Earthquake in Sicily and Southern Italy on Nov.* 16, 1894. **A. Riccò.** (Accad. Lincei Atti, 8. pp. 3–12 and 35–45, 1899.)—These papers contain a preliminary account of the investigations by the Commission charged by the Government to study the earthquake. The first deals with the intensities, isoseismic lines, and instrumental records. With the aid of information derived from 170 inhabited centres, of which 80 were actually inspected by the Commission, the area affected was divided by 10 isoseismic lines. These are shown on a map which, for purposes of comparison, gives also the isoseismic lines of the earthquake of 1783. Comparing it with a geological map, the author shows that the lines follow the outlines of the great crystalline masses. An attempt is made, but without success, at comparing the damage done to property. The failure arises from the fact that in the large centres of population houses are larger and better built than in small country places. The number of casualties was fortunately very limited, owing to warning shocks. The amplitudes of the vibrations, as registered by the seismometrograph (Brassart's smoked plate) of the Catania observatory were for the first 9 seconds less than 1 centimetre, 28 seconds later, when the maximum was attained, their north-south component measured 48 mm., their east-west component 40 mm., and their vertical component 9 mm. The duration of the earthquake was felt by persons for a few seconds only, but Vincenti's delicate instrument at Siena registered a duration of 11 minutes. The first paper concludes with a table giving the observatories' distances from the epicentre, particulars of the seismometers, registered duration of the shock, amplitude and direction of the vibrations.

The second paper deals with the velocity of the moving earth or ground, the velocity of propagation, depth of hypocentre, repetitions, and comparisons with the earthquake of 1783. The author calculates the horizontal component of the velocity of the ground from the distances to which objects were projected from the tops of buildings. The velocity varied from a few decimetres to 3·9 metres at Sinopoli. The author finds the mean velocity of propagation to be 2 kilometres per second, and, assuming that the disturbance was propagated in a spherical form, calculates the depth of the hypocentre to be 159 kilometres. But the hypothesis of constant velocity is found not to hold; as the density and elasticity of the earth's crust increase with the depth, the wave-fronts are not spherical and equidistant; making certain corrections the author determines the depth of the hypocentre to be 172 kilometres. He then considers Dutton's method of finding the depth of the hypocentre, but finds that none of the depths already found agree with it, and as it also does not agree with the scale of intensities for Rossi-Fovel, he discards it. With regard to warning shocks, Mercalli states that throughout Calabria from Nov. 10 a number of very slight shocks were recorded by instruments; and the singular fact is noted that for two months previously great excitement prevailed in Calabria, as it was said that the Madonnas of Palmi, Radicena, and Seminara, moved their eyes, perspired, &c., and some plague was expected. Touching the subject of repetitions, the author calls attention to the fact that the earthquake took place when the moon was in Perigee; altogether he counts twelve repetitions, each of which occurred when the attraction of the sun and moon was a maximum; he concludes that these coincidences cannot reasonably be attributed to chance. The author compares the earthquake of 1783 with that of 1894, and concludes that the latter may be taken as a repetition of the former; but its greatly diminished intensity gives rise to the hope that in future we may not again witness such disastrous occurrence.

A. G.

454. *Earthquake-Sounds.* **C. Davison.** (Phil. Mag. 49. pp. 31–70, Jan., 1900.)—The observers of earthquake-sounds are of great number, and differ considerably in their powers of hearing. The variety of earthquakes are also of great number. One can therefore only obtain a satisfactory idea of the nature and peculiarities of the sounds observed from a multitude of interesting descriptions, such as those given in the original paper.

The sounds are generally of low pitch; and one person may hear a sound whilst another cannot hear it in the least. Again, as the audibility of a note of low pitch depends on its intensity, a person may hear it for some time and then suddenly cease to be aware of its existence; or it may have been in existence for some time before he is conscious of the fact. Notwithstanding the difficulties due to physiological causes, from the frequent comparison of the sound to that of passing vehicles, one may say that the intensity of the sound is often of varying magnitude, and that it sometimes increases to a maximum and then dies away. In addition to the varying sound there are often erratic noises which do not always produce the same effect on all observers. Thus, "in the Hereford earthquake we find that at Hereford a crash or bomb-like explosion was noticed during the rumbling sound by four observers, while four others describe the sound in terms which imply uniformity of character."

An attempt is made to map out the area subject to the sounds with the aid of isacoustic lines. "An *isacoustic line* may be defined as a line which passes through all places in which the percentage of persons who hear the sound is the same." There are marked differences between the isoseismal and the isacoustic lines. The paper also deals with the relation between sound-audibility and geological structure, the relations between the intensities of the shock and sound, the relations between the sound area and the disturbed area, the time relations of the sound and shock, and the relative durations of the sound and shock.

Finally, a theory is given of the causes of the sounds when the earthquakes are of a non-volcanic character. The supposition is made that the majority are due to the growth of faults. The seismic centre is not a point, but "a surface inclined to the horizon, and is often of great length in a horizontal direction." It is assumed that the large and slow vibrations come from the central region, whilst the small and rapid vibrations come from the outskirts. A. G.

455. *Secchi's Fourth Type of Stellar Spectra.* **G. E. Hale** and **F. Ellerman.** (Astro-Phys. Journ. 10. pp. 87–112, Aug., 1899.)—The authors commence by stating the difficulties which have hitherto prevented any systematic examination of this group of celestial objects. None of the stars exceed the 5·5 magnitude, being thus beyond the reach of any but the largest instruments, and moreover, when examined photographically, the blue region of the spectrum is so feeble that but little is recorded with normal plates and exposures. With the instrument at the author's command, the 40-inch Yerkes refractor of the University of Chicago, the first difficulty is rendered much less noticeable, while the character of light emitted by these stars has been utilised by employing isochromatic plates and long exposures. The work was systematically commenced in 1897. After reviewing the early work by Vogel and Duner the authors give a detailed description of their apparatus, of which several illustrations are included. A special interpolating machine was designed and made for the determination of wave-lengths.

In this, the first paper on the subject, attention is confined to the star 152

Schjellerup, which is the brightest object of this class. A photograph of the spectrum of this star is given, extending from λ 4800 to λ 6300. From the evidence of their photographs, the authors consider the spectrum to contain two *bright* lines, and draw special attention to that at λ 5592. C. P. B.

456. *Wave-Length of Green Corona Line.* **W. W. Campbell.** (Astro-Phys. Journ. 10. pp. 186–192, Oct., 1899. Paper read at the Third Conference of Astronomers and Astrophysicists, Sept. 7, 1899.)—The author describes the apparatus he had charge of with the Crocker expedition sent out from the Lick Observatory to observe the total eclipse of the sun, January 22, 1898, in India. His original intention was to get photographs of the spectrum of the corona on a large scale in order to determine the law of rotation from the change of wave-length of the lines; but on examination of his plates he found the wave-length of the chief corona line in the green to be λ 5303·26, instead of λ 5316, which has been the accepted value for many years past. This had also been mentioned by Lockyer a few months previously. It is therefore important to determine the wave-length as accurately as possible at the next eclipse, as there may then be a possibility of its origin being determined.
C. P. B.

457. *Corrections to Absolute Wave-length Determinations.* **E. B. Frost.** (Astro-Phys. Journ. 10. pp. 283–285, Nov., 1899.)—In the reduction of spectroscopic observations of celestial objects it is always necessary to apply certain corrections to the observed wave-lengths on account of the various movements of the earth and other bodies, which movements cause displacements of the spectrum lines from their normal positions. Until recently two of these corrections have been neglected owing to their minuteness, but the recent advances in the accuracy attainable in the determinations of velocity in the line of sight render it important that they should in future be taken into account.

The first of these is due to the effect of the eccentricity of the earth's orbit, and varies from 0·011 tenth metre for λ 6563 to 0·007 for λ 3934.

The second correction is the diurnal one, due to the earth's rotation. This for the latitude of Baltimore would vary from 0·008 tenth metre to 0·005 tenth metre. Thus an absolute determination of wave-length might from these two causes be in error to over one-hundredth of a tenth metre, the resulting velocity being wrong to more than one-half a kilometre per second.
C. P. B.

458. *Sun-Spot of September and October*, 1898. **A. Elvins.** (Canad. Instit., Proc. 2. 2. pp. 35–38, Sept., 1899.)—The author observed the groups of the sun-spots from September 4, probably their second day near the eastern limb, to September 17, and again on their reappearance on September 27 or 29, missing only a few days, down to October 10; on October 12 the spots had disappeared. Sketches taken are reproduced. The diameter of the great spot is estimated at 43,000 miles (sun diameter 800,000). The spots changed very much in appearance. As the groups in the train of the large spot seemed to be drifting towards the latter in September and to precede it in October, he considers that dark matter floating and drifting, possibly at different levels, in the sun's atmosphere cuts off the light of the photosphere below. He does not discuss the extreme agitation observe by D. E. Hadden during two hours about noon, September 7: the Hα line wa *reversed and distorted*, black jets proceeding from each side in several places

and, on opening the slit slightly, intense scarlet flames were seen over the large spot; many lines (D_1 and D_2) were widened. Auroras were reported from many places in Canada, especially on the days when the spots were near the limbs and, still more, when in the central solar meridian; the magnetic disturbances were most marked at the latter time. A terrific hurricane swept the Windward Islands on September 10 (time of central meridian position) and another occurred at Niagara (eastern limb position). The spots were near the solar equator, but they belong to a minimum sun-spot period; as a rule, a new cycle commences far from the equator. H. B.

459. *Photographic Determination of Stellar Parallax.* **F. Schlesinger.** (Astro-Phys. Journ. 10. pp. 242–245, Nov., 1899.)—This paper, which was read at the Third Conference of Astronomers and Astrophysicists at Chicago, September 8, 1899, consists of a series of suggestions for improvements in the methods of determination of stellar parallax.

The two most important means for this research are photography and the heliometer. The author considers that while measures found by photography are not inferior in accuracy to those made with the heliometer, it has much to recommend it on the score of economy of time. The disadvantages to which photography is liable require special attention for their elimination.

The difficulty, owing to the star under examination for parallax being usually several magnitudes brighter than those with which its position is to be compared, he proposes to remedy by rendering the photographic film locally less sensitive in the region where it is known the central bright star will impress its image.

Another possible serious source of error is the chance of distortion of the film after exposure. This may be detected by a modification of Wilsing's process, viz., by taking two pictures on the same date close together on the plate; then putting the plate away without development and six months later exposing two more pictures of the same object symmetrically with the first pair on the same plate. By this means any linear distortion, however violent, will not affect the measures for parallax.

A third source of error—optical distortion—may be introduced by the frequent reversals of the telescope on its axes. This may be partially obviated by providing means for revolving the object-glass also. In measuring up the plates differential measures only should be used. C. P. B.

460. *Photometry of Orion Nebula.* **J. Scheiner** and **J. E. Keeler.** (Astro-Phys. Journ. 10. pp. 164–168, Oct., 1899.)—Keeler has obtained photographs of the Orion nebula on ordinary plates, and on isochromatic plates with a yellow screen, and finds that the two pictures, one given by the blue and violet rays chiefly, the other by the greenish-yellow part of the light, show considerable differences in the structure of certain parts of the nebulous mass. Scheiner criticises these results, drawing attention to the difficulty of comparing equal photographic effects on different plates. C. P. B.

REFERENCE.

461. *Variations of Nickel-Steels.* **C. E. Guillaume.** (Journ. de Physique, 8. pp. 553–556, Oct., 1899.)—A discussion of the changes in the expansion of bars of nickel-steel when subjected to various temperatures. (See 1898, Abstract No. 1115.) J. J. S.

LIGHT.

462. *Diffused Reflection of Light.* **H. Wright.** (Ann. d. Physik, 1. 1. pp. 17–41, Jan., 1900.)—Lambert's cosine law of diffused reflection, originally suggested by the flat aspect of the moon, has been shown to be nothing but a rough approximation, destitute both of theoretical justification and of experimental proof. The Lommel-Seeliger formula is also unsupported by the facts.

The author describes some measurements made with plates of various substances and colours in a state of powder, and of such thickness as to be just opaque. He confirms Lommel's supposition that with a given size of grain the coefficient of diffusion is independent of the wave-length. An important result obtained is that the cosine law does not apply to a constant angle of emanation and a variable angle of incidence, but that, on the other hand, the amount of light reflected varies as the cosine of the angle of emanation when the angle of incidence remains constant, at least in perfectly dull powders. There is no law which is symmetrical both as regards i and e. Natural light is not polarised by diffused reflection, but polarised incident light is completely depolarised. The observed variations from Lambert's law range from 4·6 to 10 per cent. E. E. F.

463. *Metallic Reflection.* **E. Hagen** and **H. Rubens.** (Zeitschr. Instrumentenk. 19. pp. 293–306, Oct., 1899; Mittheilung aus der Physikalisch-Technischen Reichsanstalt.)—The results of this investigation of the reflecting power of metals for the different wave-lengths, from 450 to 700 $\mu\mu$, have been already communicated to the Physical Society of Berlin. (See 1899, Abstract No. 992.) The present paper contains a detailed description of the apparatus used, which is of that magnificent type generally used in the Reichsanstalt.

The metallic mirrors used are, with a few exceptions, concave, and all of the same focal length. The source of light is a strip of platinum foil, kept incandescent by an electric current. This is placed in the focus of the mirror, then slightly displaced vertically so that the real image of the incandescent strip is seen a little lower than the strip itself. These two sources of light are then compared by a spectro-photometer. In the cases where the mirrors are plane a convex lens is placed in front of the mirror, the strip being at the focus of the lens. The amount of light absorbed by the lens is determined by comparing the results so obtained for a plane silver mirror with those obtained for a concave silver mirror of the same manufacture.

The prisms and lenses in the apparatus are of quartz, and the achromatic lenses are combinations of lenses of fluorspar and quartz. The spectrophotometer consists of a spectrometer with automatic adjustment of minimum deviation and with double slit, each slit having micrometer adjustment. A biprism is placed in front of the telescope objective, its edge being horizontal. Images of the source of light and its reflected image are thrown on the two slits by a lens in such a manner that the light which enters the two slits comes from the same part of the platinum strip, but from opposite sides of it, since one beam has been reflected. If the biprism is removed, two corresponding spectra are seen in the focal plane of the telescope. On replacing the biprism four spectra occur, two of which are exactly superposed (by adjustment). The eyepiece is then removed and a small slit placed in the

focal plane to cut off all the light, except the one wave-length in the double spectrum. The eye when looking through this slit sees the field of a uniform colour, but the upper and lower halves are not of equal intensity. Adjusting the micrometer screw of one of the slits makes the intensities equal, and the relative widths of the two slits gives the photometric comparison of the source and its image for that particular wave-length. The slits are experimentally standardised by placing a uniformly illuminated surface opposite them and photometrically comparing the spectra.

Besides the results previously given the following reflecting powers are also given here, the figures being percentages :—

For λ	450	500	550	600	650	700 μμ
Alloy of Brandes and Schünemann (41 % Cu + 26 Ni + 24 Sn + 8 Fe + 1 Sb).	49·1	49·3	48·3	47·5	49·7	54·9
Alloys of Ludwig Mach—						
No. I. (2 parts Al + 1 part Mg)...	83·4	83·3	82·7	83	82·1	83·3
No. VII. (1 part Al + 1·5 part Mg)	83·4	82·5	82·1	83·8	84·9	84·4
No. XII. (1 part Al + 2·75 part Mg)	83·4	84·5	83·8	84·5	83	83·8

The first of the above alloys withstands severe exposure to the weather, and ordinary chemical reagents have no effect on it. J. B. H.

464. *Total Reflection.* **W. Voigt.** (Gesell. Wiss. Göttingen, Nachr. Math.-Phys. Klasse, 1. pp. 1–33, 1899.)—In a former communication (Gött. Nach., 1898) the author has shown that the phenomenon of so-called total reflexion can at least approximately be regarded as the reflexion of a plane wave, whose amplitude varies in the plane of the wave, on an opaque screen, which is bounded by lines parallel to the lines of constant amplitude in the plane of the wave. He has also, following Sommerfeld, dealt with the case of a perfectly reflecting screen. The fundamental conception of the present paper is that an absolutely black screen may be regarded as the surface of separation in a multifold Riemann space, of which one part represents the physical space. A vibration excited in the physical space passes out of the physical into another part of the Riemann space. This effect of the surface of separation is at least analogous to the action of the absolutely black screen, which neither transmits nor reflects light.

The author discusses the definition of an absolutely black body. The definition that it neither transmits nor reflects light, though for some purposes sufficient, is insufficient for the purposes of physical optics, because it may act in other ways on light in its neighbourhood. There may then be different kinds of absolute blackness, and the kind dealt with in the present paper is that for which the appropriate Riemann space is twofold.

A plane wave of light reaches the screen, bounded by an infinite line parallel to the plane of the wave. The normal component passes through the screen into the other part of the Riemann space; the other component spreads over the screen, and there undergoes the variations which are known as Beugung. S. H. B.

465. *Astro-photographic Objective.* **H. Harting.** (Zeitschr. Instrumentenk. 19. pp. 269–272. Sept., 1899.)—An account of an objective for

astro-photographic work, made from a new silicate glass produced at the works of Schott and Co. in Jena. The glass exhibits such unusual behaviour as to partial dispersion that the secondary spectrum, so far as concerns the eye, is done away with, and for the purposes of astro-photography is considerably diminished. J. J. S.

466. *Portable Photometer for Incandescent Lamps.* **A. J. Rowland.** (Frank. Instit., Journ. 148. pp. 876–888, Nov., 1899.)—This describes a photometer, which the author has found especially good for candle-power of glow lamps. It is a Bunsen photometer with a movable carriage, holding the usual grease spot and mirrors. At one end of the instrument is a lamp-holder for the incandescent lamp whose candle-power is to be determined; at the other end, about 5 feet off, is an oil lamp. This holds enough oil to burn for four hours in use, and for an hour at a time with practically no change in its candle-power after once warming up and being set.

The method of working is to put a standard incandescent lamp in the holder, bring it to the required voltage by means of a rheostat, to give its standard candle-power of 16. The carriage with the grease spot is then set to this, and the 8-candle-power oil lamp is adjusted until the grease spot disappears. The standard lamp is then replaced by the one to be measured, and the carriage moved to give the reading in the ordinary manner.

This method of procedure does away with all difficulty due to reflection, difference in quality of the sides of the greased paper, difference of eye sensitiveness, &c., and does away with them all to such an extent that a real dark room is not required to get satisfactory results. All distortions come into every measurement in exactly the same way, and are negligible. The accuracy of a single reading will be within 1½ per cent. E. C. R.

467. *Standards of Light.* **S. E. Doane.** (Amer. Instit. Elect. Engin., Trans. 16. pp. 451–458. Discussion, pp. 458–461, Aug., Sept., 1899.)—The author suggests that the incandescent lamp should be used as a primary standard. In the discussion **Steinmetz** pointed out that an acetylene standard could be used owing to the fact that the gas can easily be produced in chemical purity from copper acetylide Cu_2C_2, and that its light is of a perfectly white colour, equally suitable for incandescent and arc light photometry. The amyl acetate standard, the best available at present, has a great number of disadvantages, especially as regards colour. **C. P. Matthews** preferred the amyl acetate standard because of its steadiness and reproducibility. **W. M. Stine** pointed out that the failure of the incandescent light as a standard is due to its lack of reproducibility and constancy. The essential difficulty arises from the tendency of carbon to assume an allotropic form at a very high temperature; it is also impossible to produce homogeneous carbon filaments or to flash filaments until the surface assumes known radiating qualities. There are other difficulties such as the variation in the emissivity (both in the same filament and between different filaments), the blackening of the chamber walls, their indefinite absorption, and the vaporisation of the filament. **S. E. Doane,** in replying, said that he made a series of investigations and found that carbon surfaces of the two kinds gave only two emissivities; that is, all "treated" carbons gave exactly the same illumination per unit surface per watt radiated. There was absolutely no difference over wide ranges of specific resistance and specific gravity of these carbon deposits. Deposits can be made from any hydrocarbon, alcohol, or carbonaceous fluid and the light radiated per unit surface per watt will be the same. E. C. R.

468. *Effect of Impurities on Gaseous Spectra.* **P. Lewis.** (Astro-Phys. Journ. 10. pp. 137–168, Oct., 1899.)—For many years the fact has been known that a small quantity of an impurity introduced into a gas considerably alters the appearance of the gaseous spectrum. The author has made a systematic examination of the effect of small additions of mercury vapour, oxygen, and water vapour on the spectra of hydrogen and oxygen. Special precautions were necessary to ensure the initial purity of the gases, and illustrations are given of the apparatus used. In the case of hydrogen, the introduction of mercury vapour caused a distinct reduction in the intensity of the hydrogen lines, the extent of the change varying with the quantity of mercury vapour present. With the hydrogen at 3 mm. pressure, the addition of 4 per cent. of its mass of mercury vapour reduced the visible radiant energy of the hydrogen by more than one-half. The effect of small quantities of oxygen added to hydrogen was also to reduce the intensity of the hydrogen spectrum, but to a greater extent than was the case with mercury-vapour. Water vapour also behaved very similarly to oxygen. In the case of the spectrum of oxygen, the addition of mercury vapour caused no change, but the least addition of hydrogen caused the mercury lines to be instantly visible. Throughout the experiments different results were obtained by the use of vacuum tubes having internal or external electrodes. C. P. B.

469. *Spectroscopy of Contrast Phenomena.* **G. J. Burch.** (Electrician, 43. pp. 811–812, Sept. 29, 1899. Abstract of a paper read before the British Association at Dover.)—In the words of the original, "The author has shown that by exposing the eye to bright sunlight in the focus of a burning glass, behind a screen composed of ordinary ruby glass, in conjunction with a gelatine film stained with magenta, a condition of temporary red-blindness may be induced, during which red flowers, such as scarlet geraniums, appear black, and red roses blue, although the observer is still perfectly able to distinguish colours composed of green, blue, and violet. Similarly, blindness to green, to blue, or to violet may be produced by fatiguing the retina with monochromatic light of sufficient intensity and of suitable colour. Experiments of the same character by Aitken, Hunt, Hess, and others, have since been brought to the author's notice. His own, which were made quite independently many years ago, differ from theirs in degree rather than in kind, the light used by these observers having apparently been not sufficiently intense to produce the full effect. . . . On Young's hypothesis all complementary colours and all contrast effects may be represented as coming under the same category as absorption spectra, in that they are due to the subtraction of something from the normal sensations which should result from the physical conditions of the experiment. According to Hering's theory, complementary colours cannot be regarded as due to the mere absence, or diminution, or suppression of certain elements of a complex sensation. So far as regards the effect of continuous light, the phenomena of artificial colour-blindness seem conclusive against the view of Hering." [See further Abstract No. 753 (1898).] E. E. F.

470. *Radiography with Three-phase Currents.* **Delézinier.** (Comptes Rendus, 129. pp. 1227–1228, Dec. 26, 1899.)—The employment of three-phase currents for radiography, by means of tubes with three poles, was theoretically indicated two or three years ago. Radiguet showed last year that when an induction coil is connected with two of the three terminals of a three-phase circuit, a Tesla flame appears between the terminals of the secondary. A tube does not light up unless the exhaustion is diminished, and then it lights

up throughout for an instant only and breaks. The author solves the problem by interposing an electromagnet with laminated core, consisting of two straight branches mounted at an angle of 120° and provided with two coils wound in opposite senses, in the primary circuit. The Wehnelt interrupter then works well for hours, and the light of the tube is so uniform and perfect that its intermittence can only be detected by stroboscopic methods. Of variable-rate interrupters, that consisting of a vertical coil with its lower end in mercury works best, especially if it be so regulated that the phase utilised is between $\frac{1}{2}\pi$ and $\frac{3}{2}\pi$. When the terminals of the indicator are reversed, the illuminated zone is not displaced. It is just as active photographically, and only a little less effective on the screen. E. E. F.

471. *Fluorescence in Solids.* **I. Schincaglia.** (N. Cimento, 10. pp. 212–223, Sept., 1899.)—In isotropic substances the light of fluorescence is never polarised : in crystals it generally, but not always, presents traces of polarisation. Topaz is the only crystal in which this light is completely polarised. Fluorescence of crystals depends in the greater number of instances upon chemical impurities in them, probably distributed in accordance with the structure of the crystal. In a crystal the particles causing fluorescence tend to vibrate either parallel or at right angles to the optic axis of the crystal. The colour of a crystal has no influence upon the production of fluorescence, but may affect the colour of the fluorescent light, if such be produced. In some cases the interposition of violet glass affects the colour of the fluorescent light produced. A magnetic field seems to produce no effect upon the colour of the fluorescent light, and not to cause anything analogous to the Zeeman effect. A. D.

472. *Phosphorescence of Used Röntgen Tubes.* **S. Leduc.** (Écl. Électr. 21. pp. 143–144, Oct. 28, 1899. Assoc. Franç. at Boulogne.)—A Röntgen tube after working remains luminous in the dark, with a uniformly distributed white light. This luminosity can be started afresh by heating the tube, and is a maximum at a particular temperature. It is not due to rarefied gas in the tube, for the result is the same if the tube have become filled with air. The glass of the Röntgen tube before being used does not present this phosphorescence ; it is an acquired property, apparently due to the action of high-tension electricity. The property is lost on repeated heating. A. D.

473. *New Radio-active Element.* **A. Debierne.** (Comptes Rendus, 129. pp. 593–595, Oct. 16, 1899.)—Another new element, bearing a close chemical analogy to titanium, found in the residues of pitch-blende. The radioactivity is a hundred thousand times that of uranium ; and the radiations render gases capable of discharging electrified bodies, excite fluorescence in platinocyanide of barium, and affect photographic films. The new substance is not, like radium, self-luminescent. A. D.

474. *Phosphorescent Sulphides.* **F. E. Kester.** (Phys. Rev. 9. pp. 164–175, Sept., 1899.)—A vertical cylinder of the test substance was rotated about its axis and was illuminated on one side through an aperture placed quite close to the cylinder. Then the emitted light was examined by a spectrometer, the slit of which was diametrically opposite the illuminating aperture. With a constant intensity of the source of illumination and a constant speed of rotation, however slow, the intensity of the emitted light, as observed in the spectrometer, remains the same. The energy of the exciting radiations

was measured by the deflections produced in a form of Crookes' radiometer. It has been found that under proper conditions the deflections are proportional to the energy of the radiations.

Observations were made upon calcium sulphide. The luminosity of the sulphide was found to be proportional to the intensity of illumination, under the conditions of the apparatus. For all wave-lengths of exciting light, widths of aperture, and speeds of rotation which were tried, it was found that the curves of intensities were straight lines. The results indicate that the rate of increase or of decrease at any intensity of phosphorescence depends upon the previous treatment which the luminous material has undergone.

J. J. S.

REFERENCES.

475. *Radiographic Vacuum Tubes.* **A. Buguet** and **V. Chabaud.** (Comptes Rendus, 129. pp. 591–593, Oct. 16, 1899.)—Description of focus tubes with the antikathode cooled, at its back surface, by a circulating stream of water. A. D.

476. *Refractive Indices of Crystals.* **C. Viola.** (Zeitschr. Instrumentenk. 19. pp. 276–282, Sept., 1899.)—A new method for determining the refractive indices of biaxial crystals is described. The method depends on the principle of minimum deviation, and a prism is employed. It is shown that this principle may be made use of for general purposes. (See also 1899, Abstract No. 1652.) J. J. S.

477. *Radiation Phenomena in a Magnetic Field.* **T. Preston.** (Nature, 61. pp. 11–13, Nov. 2, 1899.)—A short summary of some of the results obtained by the author in his investigations on this subject, especially with reference to their date of publication. It appears that the quartet form was first observed by the author in 1897 and its existence was independently proved by M. Cornu in the following year and announced in the *Comptes Rendus.* (See Science Abstracts, 1898, Nos. 910 and 1032, and Science Abstracts, 1899, No. 1000.) J. J. S.

478. *Magneto-Optic Rotation.* **A. Gray.** (Nature, 60. pp. 379–381, Aug. 17, and 404–407, Aug. 24, 1899.)—Discourse delivered at the Royal Institution. An account of the phenomena and theories of magneto-optic rotation with mechanical illustrations. J. J. S.

479. *Colour Photography.* **W. de W. Abney.** (Roy. Instit., Proc. 15, pp. 802–809, Aug., 1899.)—A description of Ives' and Joly's processes, and the principles involved. G. H. B.

480. *Photometry of Electric Incandescent Lamps.* **E. Liebenthal.** (Zeitschr. Instrumentenk. 19. pp. 193–205, and 225–240, 1899.)—A full experimental account, with mathematical discussions, of methods for measuring the mean spherical intensity and the particular variations from this, in differing types of lamps. A. D.

481. *Lummer-Brodhun Photometer.* **C. G. Knott.** (Phil. Mag. 49. pp. 118–120. Jan., 1900. Paper read before the Royal Society of Edinburgh, Dec. 17, 1899.) —Priority is claimed for W. Swan for the invention of this photometer, described by him in 1859.

482. *Telescope and Microscope Objectives.* **A. Leman.** (Zeitschr. Instrumentenk. 19. pp. 272–273, Sept., 1899.)—A discussion of formulæ for use in calculations applied to objectives of telescopes and slightly magnifying microscopes. J. J. S.

HEAT.

483. *Thermal Conductivity of Vulcanite.* **B. O. Peirce.** (Phil. Mag. 49. pp. 15–31, Jan., 1900.)—To measure the conduction of materials like vulcanite or glass, prisms were built up consisting of plates of the material, separated by layers of tin-foil; the faces of the prism were kept in contact with a steam supply and a reservoir of ice. Thermocouples inserted between the plates gave the temperature gradient and the amount of ice melted—the drip from the ice becomes steady when the experiment is continued for some hours—gave the flow of heat. The influence of the edges of the prism was shown to be negligible. The most suitable thermocouple consisted of thin strips of German silver and copper soldered end to end. The conductivity of vulcanite varies, according to the manufacture, from 0·000200 to 0·000317.

R. A. L.

REFERENCES.

484. *Pressure and Evaporation.* **E. H. Hall.** (Journ. Phys. Chem. 3. pp. 452–456 Oct., 1899.)—In a reversible isothermal process the volumes of the products on either side of the equation are not necessarily equal, and a correction should be introduced into the "equation of the reaction-isotherms" (Nernst, Theoretische Chemie, Ed. I., p. 510). The author applies the corrected equation to the evaporation of water and ice. T. M. L.

485. *Ratio of Specific Heats of Air.* **J. Rose-Innes.** (Phil. Mag. 48. pp. 286–287, Sept., 1899.)—A criticism of E. F. J. Love's paper on the Joule Thomson Thermal Effect. (See 1899, Abstract No. 1355.)

486. *Gaseous Mixtures.* **D. Berthelot.** (Journ. de Physique, 8. pp. 521–530, Oct., 1899.)—This memoir embraces little more than those referred to in Science Abstracts for 1898, No. 1231, and for 1899, No. 1153, as well as one (not abstracted) in Comptes Rendus, 128. pp. 1159–1160, 1899, which merely gives data to illustrate a former memoir. R. E. B.

487. *Thermodynamics.* **G. Jäger.** (Ann. d. Physik, 69. 3. p. 720, Nov., 1899.)—A short reply to W. Voigt *re* thermodynamics. E. E. F.

488. *Dilatation of Porcelain.* **T. G. Bedford.** (Phil. Mag. 49. pp. 90–97, Jan., 1900.)—This is a detailed account of the experiments referred to in Science Abstracts for 1899, No. 1880. R. E. B.

ELECTRICITY.

489. *Travelling Globular Spark.* **S. Leduc.** (Écl. Électr. 21. pp. 142–148, Oct. 28, 1899. Paper read before the Assoc. Franç. at Boulogne.)—Two fine polished metallic points arranged from 5 to 10 cm. apart, at right angles to a photographic plate or glossy gelatino-bromide paper, and connected with an electrostatic machine, will, especially if the paper rest upon a piece of glass and this upon a plate of metal, produce an effluvium round the positive and a luminous globule at the negative point. When the luminous globule has attained a certain size it detaches itself from the negative point (which becomes dark), and travels over the plate or paper, by a more or less irregular path, sometimes dividing as it travels, towards the positive point. When it reaches this, all luminosity is extinguished and the charges disappear as if the terminals of the machine had been connected by a conductor. If the positive point be lifted and laid down at a fresh place the phenomena recur in the same order. The globule takes from one to four minutes to travel the 5–10 cm. (See also 1899, Abstract No. 451.) A. D.

490. *Analysis of Spark Discharges.* **J. H. West.** (Elektrotechn. Ztschr. 20. pp. 747–750, Oct. 26, 1899.)—A photographic analysis of spark discharges was made by means of a "mutograph" in which the film was made to travel continuously with a speed of 1 to 7 m. per second. The sparks were produced with the aid of a Wehnelt interrupter. They travelled along approximately the same paths during successive discharges, but did not succeed each other regularly. On the negatives reproduced the sparks differ greatly in brightness. Their diameter is not uniform, and they are frequently brighter in the middle than at the ends. Some of the sparks are double or multiple, but these are not due to two or more simultaneous discharges, but to several sparks following in rapid succession, as shown by their tracks not being strictly parallel but approaching each other the closer the more their direction coincides with the direction of motion of the film. Continuous current sparks do not show these doublings or branchings. By direct vision the author proves that a duration of luminosity of about one-millionth of a second suffices to produce a distinct visual sensation. E. E. F.

491. *Radiations from an Electrified Point.* **S. Leduc.** (Écl. Électr. 21. pp. 144–145, Oct. 28, 1899. Assoc. Franç. at Boulogne.)—Insulate one pole of an electrostatic machine, and connect a fine point with the other, preferably the negative. This fine point presents a barely visible violet glow, but is the seat of powerful non-luminous radiation, possessing all the properties of ordinary ultra-violet rays, and capable of being used for photographic purposes. The photographic image of the source of radiation is a point. The rays are completely arrested by yellow, green, and red glass; and there is no resemblance to Röntgen rays. Leduc proposes the use of these rays in medical practice, *e.g.*, for lupus, as a convenient means of applying the known chemical effect of ultra-violet rays. A. D.

492. *Induction Coil Spark on Heating the Terminals.* **F. J. Jervis-Smith.** (Phil. Mag. 48. pp. 477–478, Nov., 1899.)—An Apps 10-inch induction coil, with a Wehnelt *electrolytic break in the primary circuit;* the pointed conductors

from the secondary coil so far separated that a spark would not pass and only a faint brush was visible; on heating the kathode terminal (not the anode) with a spirit lamp flame, sparks at once bridged the gap. Possibly the kathode point showered off heated metallic particles which enabled the sparks to pass along a heated path. A. D.

493. *Luminescence of Immersed Electrodes.* **T. Tommasina.** (Comptes Rendus, 129. pp. 957–959, Dec. 4, 1899.)—The author observed the luminescence of electrodes under the influence of the discharge of an induction coil. He filled some ordinary Crookes tubes with distilled water. The electrodes were aluminium discs attached to platinum wires. The discs became luminous, and so did the supporting wires when of aluminium instead of platinum. In many places minute gas bubbles traversed by sparks were observed, but the luminosity was not confined to those places. The discs could be photographed by their own light. The glow is essentially anodic, as evidenced by the fact that the current at break makes the anode luminous, and the current at make the kathode. The luminosity, though apparently continuous at both electrodes, is really alternating. Only aluminium, and to a less extent magnesium, show this luminosity, and they only show it when immersed in water, alcohol, or acidulated water, and not in dielectrics like petroleum or vaseline. E. E. F.

494. *Dispersion of Kathode Rays by Magnetic Force.* **R. J. Strutt.** (Phil. Mag. 48. pp. 478–480, Nov., 1899.)—Birkeland finds that when a narrow beam of kathode rays, produced by an induction coil, is deflected by a magnetic field, some of the rays are more deflected than others and the rays as a whole are so deflected as to produce by their impact a series of light bands of phosphorescence and intervening dark spaces. This Birkeland calls the magnetic spectrum. The author finds that there is no such spectrum when the kathode rays are produced by the continuous discharge of a battery of storage cells. The heterogeneity of the deflected rays is therefore not an essential property, but depends on some peculiarity of the induction-coil discharge, the kathode rays produced by a battery being homogeneous. The bright bands probably do not really coexist but depend on discharges occurring at different stages of each alternation. A. D.

495. *Energy of Kathode Rays.* **W. Cady.** (Deutsch. Phys. Gesell., Verh. 1. pp. 181–192, 1899.)—In the discharge of kathode rays on the theory of emission of charged particles, we have the energy Q (of N particles each of mass m and with velocity v) $= \frac{1}{2}Nmv^2$ ergs per second: and the current strength $i = N\epsilon$ where ϵ is the charge borne by each particle. For each particle the energy $V\epsilon = \frac{1}{2}mv^2$; so that the whole energy, in ergs per second, is $Q = NV\epsilon = iV$, and $iV/Q = 1$. But if part of the kathode rays are reflected, say the fraction r, and if the energy of the particles is reduced upon reflexion in the ratio $r' : 1$ while the reflected particles retain their charges, we have $iV/Q = (1-r)/(1-rr')$; or in the limit, if Merritt's result be accepted, that the magnetic deflectability, and therefore the velocity of the kathode rays, remains unaltered after reflection, $iV/Q = 1 - r$. Experiment shows that when we work within limits at which there is no superposition of conduction upon kathode convection, the value of iV/Q varies between 0·79 and 1·00. A. D.

496. *A Cyclical Electric Process.* **O. Dörge.** (Ann. d. Physik, 1. 1. pp. 1–16, Jan., 1900.)—A soap-bubble is taken through an electrical process

analogous to Carnot's thermodynamic cycle. In the first operation the soap-bubble is extended infinitely slowly while in contact with a conductor of very great capacity at a potential V_1. It is then disconnected, and further extended until the potential falls to another potential V_2. It is then connected with another conductor of great capacity at potential V_2 and contracted, and finally disconnected and further contracted until it reaches its initial stage. The author shows that the work done during the cycle is—

$$\frac{V_1}{8\pi}(V_1 - V_2)(r_b - r_a)$$

when r_a, r_b are the radii of the soap-bubble at the beginning and the end of the first operation respectively.

A counterpart of the second law of thermodynamics is obtained in the proposition that "no process is possible consisting only of a transfer of electric energy from a higher to a lower potential without the absorption or giving out of work." The author attempts to prove his conclusions experimentally, but with only partial success. Quantitatively the conclusions are, however, corroborated. E. E. F.

497. *Irreversible Processes.* **M. Planck.** (Ann. d. Physik, 1. 1. pp. 69–122, Jan., 1900.)—This is an exposition of the chief results of the author's investigations on the significance of the second law of thermodynamics for the phenomena of thermal radiation, considered from the point of view of electromagnetic theory of light. The phenomena of radiation and absorption are regarded as altogether electromagnetic, in the sense of being confined to the oscillation and resonance of certain entities analogous to Hertzian oscillators, connected in some way with the atoms of matter. This implies that the damping of an oscillator is entirely due to its radiation, and not, for instance, to Joulean waste. Optically, a wave-train of light is perfectly defined when its geometrical relations, its plane of polarisation, its intensity, and its wave-length are given. Electromagnetically, such a wave-train is by no means completely defined, since, owing to peculiarities in the distribution of the phases and amplitudes of the partial vibrations, its effect upon a resonator can have an infinite number of different values. The author eliminates this difficulty by introducing the conception of "natural radiation," in which the energy is distributed with absolute irregularity over the different partial oscillations composing the ray. This conception leads to the formulation and proof of a theorem analogous to the second law of thermodynamics. Incidentially, the author defines what he calls the "natural units" of length, mass, time, and temperature, which are independent of any particular body, such as the earth, and solely founded upon the velocity of light, the gravitational constant, and certain constants of radiation. The natural unit of length thus calculated is $4{\cdot}13 \times 10^{-33}$ cm., that of mass is $5{\cdot}56 \times 10^{-5}$ g., that of time $1{\cdot}38 \times 10^{-43}$ sec., and that of temperature $3{\cdot}50 \times 10^{32}$ deg. C. (See also 1899, Abstract No. 268.) E. E. F.

498. *Potential Gradient in Siberia.* **H. Benndorf.** (Akad. Wiss. Wien., S. ber. 108. pp. 341–370, 1899.)—An interesting account of observations of atmospheric potential gradient at Tomsk in midwinter. The practical difficulties are narrated. The results do not fully confirm any existing theory, but may be to some extent harmonised with them if dry ice or snow have, as Brillouin says it has, a negative-electricity-discharging sensitiveness to light about one-twentieth that of zinc. A. D.

499. *Atmospheric Potential Gradient in Egypt.* **F. Exner.** (Akad. Wiss. Wien., S. ber. 108. pp. 371–421, 1899.)—The author's formula $dV/du = A/(1 + Kp_o)$ where dV/du is the normal atmospheric potential gradient and p_o is the proportion of water vapour in the air, is now amply confirmed. It would seem as if a part of the negative charge of the earth was associated with water vapour, and varied in its vertical distribution. But there are variations of which this gives no explanation : and the effect of variations in the intensity of sunlight and in the temperature is, according to Quetelet and Braun respectively, to bring about such variations which, however, must run closely parallel to those associated with variations in the water vapour. According to Hallwachs, the intensity of blue and ultra-violet radiations, J, affects the potential gradient by promoting the direct discharge of negative charge, such as that borne by the earth, into the air ; and the law of the result is $dV/du = A/(1 + kJ)$. This effect is not confined to metals, as was at first thought ; and though it is small with rock-surfaces, these surfaces are great. In order to ascertain whether water vapour or solar radiation is the more effective, the author instituted observations at Luxor in order to obtain data to compare with those previously obtained by him in the damp atmosphere of Ceylon. The data obtained are given at length ; and from these it appears that negatively charged dust produces disturbances in the distribution : that in Luxor there is a well-marked maximum of potential gradient at 7 a.m., and a better marked one at 8 p.m., with intervening minima at 3 a.m. and at midday : that the average gradient is 128 volts per metre, and the maxima and minima may possibly be due to regular fluctuations in the distribution of the air-borne dust ; that in Ceylon the gradient remains appreciably the same during the twenty-four hours, with the exception of a slight rise at midday : that at Luxor the solar radiation is about 1½ times as great at midday and twice as great in the afternoon as it is at Vienna, Salzburg, or Wolfenbüttel, or, approximately, in Ceylon ; that the maxima and minima at night as well as by day tell against Hallwachs' photoelectric explanation of the variations ; that the absolute values of the potential gradient are also in disaccord with it, as also the considerations that Ceylon presents clear sky only in January and February ; and that at Luxor, with its minimum average of 128 volts per metre, the nature of the surface is much more favourable to photoelectric effect than that of the vegetation and open sea of Ceylon, so that the potential gradient ought to be less reduced in Ceylon than it is in Luxor, whereas there it is only 57 volts per metre. The photoelectric theory would also lead us to expect the potential gradient to be less steep at a height, whereas it is steeper. These considerations put the photoelectric effect down to the level of a subsidiary phenomenon ; but the data agree quantitatively with the water-vapour theory, allowing that the theoretical average of 150 volts per metre, with the average water-vapour pressure of 7·2 mm. at Luxor is correctly represented by the observed average of 128 volts per metre which is certainly somewhat too low on account of the disturbance produced by negatively charged dust. So far as observations have gone, the atmospheric electric currents alleged to be due to insolation, and to bring back to the earth the negative charges transferred to the atmosphere, are more in accord with the water-vapour theory than with the photoelectric theory pure and simple. The water vapour will itself carry the negative charges and restore them to the earth upon condensation. Braun's theory that the potential gradient falls with rising temperatures, is untenable : Ceylon (57 V per metre) has the same temperature as Luxor (128 V/m) ; and in Siberia the potential gradients remain the same between — 40° and + 30° C. A. D.

500. *Atmospheric Electricity during a Solar Total Eclipse.* **R. Ludwig.** (Akad. Wiss. Wien., S. ber. 108. pp. 436–444, 1899.)—Observations at Jeur, Deccan, Bombay Presidency, during the total eclipse of January 22, 1898; height 600 to 700 metres; apparatus, Exner's. The potential gradient fell from 150 to 120 volts per metre as totality was approaching, and went on falling to 89 for 30 minutes after it was over. The mean value of the potential gradient before the darkness was 131 volts per metre; water vapour, 8·3 mm.; temperature, 18·2° C.; potential gradient, calculated from Exner's water-vapour formula, 134 volts per metre. Potential gradient of Bombay (Exner) 64. The potential gradient clearly does not depend primarily on the temperature, and in order to support Elster and Geitel's photoelectric theory, Bombay being at a lower level should have had a higher potential gradient than Jeur, and during an eclipse the potential gradient should have risen. A. D.

501. *Balloon Measurements in Atmospheric Electricity.* **J. Tuma.** (Akad. Wiss. Wien., S. ber. 108. pp. 227–260, 1899.)—Observations and discussions. The leading features of the observations were that in some cases the potential gradients were reversed between particular altitudes, passing through zero values which in some instances were adhered to for some distances, in one case 600 metres, so that it seemed as if independently charged masses of air gave rise to the phenomenon; that the proportion of moisture in the air seemed to have nothing to do with this, and that even the presence of clouds does not determine any particular result; that the curve-lines obtained are sometimes very jerky; that positive potential gradients fall off with increase of altitude and therefore positive charges are accumulated in the atmosphere: and that there was no disturbing charge on the balloon itself. Cases have repeatedly occurred in which captive balloons have caught fire on being hauled down: possibly because they had acquired a high potential charge which there had not been time to dissipate, and which produced a spark at the valve. The danger might be obviated by throwing down a thin wire connected with the valve which would make an earth connection before the balloon reached ground. A. D.

502. *Dark Lightning-Flashes.* **W. J. S. Lockyer.** (Nature, 60. pp. 570–574, Oct. 12, 1899.)—The author here discusses the possibility and probability of the objective existence of dark flashes. He remarks at the outset that many *apparent* dark flashes as seen by the eye are probably due to retina fatigue, and so have only a subjective existence. Photography also may be deceptive, owing to the phenomenon of photographic reversal. A. W. Clayden, in 1899, put forward the following explanation of the apparent dark flashes shown by photography: If the lens be covered the moment after a flash has occurred, the developed image is always bright. If, however, after the flash has passed, the plate be exposed either to the continued action of a feeble diffused light or to the powerful glare arising from one or more subsequent flashes, then, on development, the image of the original flash will probably come out black. The present author then proceeds to test this explanation as applied to a number of very striking photographs exhibiting bright and dark flashes. He also took photographs of sparks from an induction coil with and without subsequent exposure to light reflected from burning magnesium. The examination of all these cases leads to an entire corroboration of Clayden's hypothesis. E. H. F

503. *Cause of Dark Lightning and the Clayden Effect.* **R. W. Wood.** (Science, 10. pp. 717–721, Nov. 17, and Nature, 61. pp. 104–105, Nov. 30, 1899.)—A. W. Clayden has explained the presence of dark lightning-flashes in photographs by the peculiar photographic reversal now known as the Clayden effect. The present paper seeks the explanation of this effect, and finds it in the short duration of the initial flash. This renders the part of the plate acted upon less sensitive. Accordingly, the track of the flash in question comes out dark if, after the passage of the flash, the plate is further exposed to the continued action of light from ordinary sources. The paper establishes these points by a series of experiments which are briefly as follows: The Clayden effect was repeatedly obtained from electric sparks, but could not be obtained when the filament of an incandescent lamp was substituted for the spark. This showed that the spark had something necessary to the effect sought which the incandescent filament lacked. It was next shown that this quality was not intensity. It was subsequently shown that the photographic reversal under examination did not depend upon the wave-length of the radiation used. It then occurred to the experimenter that the time element might be vital to the problem. The light of the spark used lasted $\frac{1}{30000}$ of a second, and might differ in its action from a weaker light of longer duration. This was first tested by photographing (1) a single spark passing through a capillary tube with the lens wide open, and (2) four such sparks superimposed on the plate, but with the lens stopped down to one-quarter of its former aperture. The plate was then fogged in the usual manner, and on development the single discharge was reversed, but the composite one was not. To demonstrate conclusively that the time factor is the only one, the light from the crater of an arc lamp was focussed upon the point of coincidence of two slits. One of these was a radial slit in a disc driven at high speed, so as to give an exposure of $\frac{1}{35000}$ of a second. The anticipated reversal of the photographic image was obtained. E. H. B.

504. *Multiple Lightning-Flash.* **A. E. Kennelly.** (Elect. World and Engineer, 34. pp. 651–652, Oct. 28, 1899.)—This paper illustrates and describes the lightning-flash photograph, in which fourteen distinct bands are discernible. The photograph was taken by J. M. Justice, at Philadelphia, on August 10, 1899. E. H. B.

505. *Multiple and Dark Lightning-Flashes.* **E. Thomson.** (Elect. World and Engineer, 34. p. 738, Nov. 11, 1899.)—The author dismisses dark lightning as a myth due to contrast effects when seen by the eye, and, when photographed, to peculiarities of the photographic plate sensitiveness, now cleared up by Clayden's experiments. The phenomenon of multiple lightning is attributed to the transfer by wind of the streak of hot air through which a succession of discharges is passing. E. H. B.

506. *Spark Potential.* **A. Orgler.** (Ann. d. Physik, 1. 1. pp. 159–174, Jan., 1900.)—The object of the author's work was the definition of the spark potential in gases by one or more constants which are solely dependent upon the substance through which the discharge takes place, and not, like the electric strength, upon the width of gap and the pressure. Paschen's rule that a constancy of the product P*d* of pressure and width of gap means a constant discharge potential, was very approximately confirmed at higher differences of potential, but not at lower ones. A quantity which is really characteristic

of the various gases is obtained by making the spark-gap infinitely small. Then there is still a finite difference of potential required to bridge it. In other words, the gap has an infinite resistance. The author defines as "specific electric strength" the ratio of the difference of potential required to perforate the gas to that required to perforate air under the same conditions. For hydrogen this ratio is 0·563, for CO_2 and oxygen 0·888, and for nitrogen 1·050. E. E. F.

507. *Polarisation of Dielectrics.* **H. Pellat.** (Annal. Chim. Phys. 18. pp. 150–181, Oct., 1899.)—In this paper the question is considered of the gradual absorption of electricity by condensers and of their residual charges.

Experiments were made to prove that this is a true dielectric polarisation independent of conduction, by the plan of splitting a dielectric sheet subjected to electric stress into two sheets, and then showing that on each of these sheets the total charge is zero, though all the time the sheets remain electrically strained.

Formulæ are obtained, somewhat similar to those adduced by Maxwell, by means of the following assumptions, and are shown to be not inconsistent with experiments made by Currie and also with some made by the author. The assumptions made are that the specific inductive capacity is an invariable quantity. That there is in addition an electric polarisation throughout the dielectric which increases with the time and owing to which there is a gradual increase in the apparent electrification of the surfaces. The final value of the polarisation for any given dielectric is proportional to the field. The rate of growth of the polarisation for a given dielectric is proportional to its deficiency at any moment from its final value.

Three constants thus should express the properties of a dielectric, but the author admits that it may be necessary to assume two or more superimposed polarisations in some cases, with a corresponding increase in the rate of growth constants. F. T. T.

508. *Resistance of Saline Solutions in Movement.* **A. Amerio.** (N. Cimento, 10. pp. 276–278, Oct., 1899.)—The author concludes that Bosi's experiments, though exact, are not conclusive, for the apparatus permitted alterations in the concentration. Hayward (and Hall, below) used low speeds as Bosi did, and got no positive alteration of the resistance of a solution; Edlund got positive results at high speeds. Bosi's experiments are not inconsistent with either of these results.

References:—Edlund, Ann. d. Phys. u. Chemie, v. 156. p. 251, 1875; Bosi, N. Cimento, 5. p. 249, 1897; Hall, Phys. Review, 7. p. 246, 1898. A. D.

509. *Conductivity of Dilute Amalgams.* **A. Larsen.** (Ann. d. Physik, 1. 1. pp. 123–131, Jan., 1900.)—A simple relation between concentration and electric conductivity is only exhibited by amalgams when they are very dilute. The author examined the conductivities of the amalgams of lead, zinc, cadmium, tin, and bismuth, at temperatures ranging from 0 to 100°, and compared them in every case with that of pure mercury at the same temperature. The general result obtained is that the relative conductivity increases with the temperature and with the concentration of the amalgam. This rule holds good up to the point of saturation of the amalgam, which occurs at a concentration of about 1·6 per cent. in lead amalgams, 2 per cent. in zinc amalgams, and about 5 per cent. in cadmium amalgams. All the results indicate that in dilute amalgams the metal is dissociated, and this dissociation, as generally in solutions, increases with the temperature. E. E. F.

510. *Conductivity of Copper.* (Engineering, 68. p. 804, Dec. 22, 1899.)—This is the report of a committee formed of representatives of the Institution of Electrical Engineers, the General Post Office, and the principal manufacturers of rubber insulated cables to determine a standard of conductivity of copper.

The committee resolved: (1) That Matthiessen's standard of 0·153858 standard ohms resistance for a wire 1 metre long, weighing 1 gramme at 60° F. be taken as the standard for hard drawn high conductivity commercial copper. (2) That hard drawn copper be defined as that which will not elongate more than 1 per cent. without fracture. (3) That Matthiessen's standard of 0·150822 standard ohms resistance for a wire 1 metre long, weighing 1 gramme at 60° F. be taken as the standard for annealed high conductivity commercial copper. (4) That copper be taken as weighing 555 lbs. per cubic foot at 60° F., which will give a specific gravity of 8·912. (5) That Messrs. Clarke, Forde, and Taylor's temperature coefficient, as published in their pamphlet, dated February 20, 1899, be adopted, and that an average coefficient of 0·00238 per degree Fahrenheit be adopted for commercial purposes. (6) That the resistance and weight of conductors be calculated from the actual length of the wires. (7) That a lay of twenty times the pitch diameter be taken as the standard for the calculation of tables. (8) That 2 per cent. variation of resistance or weight be allowed in all conductors. (9) That an allowance of 1 per cent. increased resistance, as calculated from the diameter, be allowed on all tinned copper between Nos. 22 and 12 gauges inclusive. W. G. R.

511. *Thermo-magnetic Transverse Effect in Bismuth.* **E. Yamaguchi.** (Ann. d. Physik, 1. 1. pp. 214-224, Jan. 1900.)—When a plate of bismuth is traversed by a current of heat and at the same time exposed to a magnetic field at right angles to its plane, an E.M.F. is generated in the plate in a direction normal to the heat current. If a man were to stand in the magnetic lines of force so that they proceeded from his feet to his head, and were to look in the direction of the heat current, the E.M.F. would be directed towards his right hand. This effect has been termed the thermo-magnetic transverse effect by its discoverers, Ettinghausen and Nernst. Symbolically, the effect is approximately governed by the equation—

$$q = -\beta \frac{\delta t}{\delta z} HQ_t,$$

where q is the E.M.F., β the distance between the terminals of the circuit, and Q_t, a function of the temperature. Putting $HQ_t = m$, it is found that m is nearly proportional to the increase of resistance experienced by bismuth in the magnetic field. In his experiments on this subject the author finds that both these quantities increase very rapidly at the lowest temperatures, being doubled or trebled as the temperature falls from 80° to 120°. For a full elucidation a better knowledge of the thermal conductivity of bismuth is essential. E. E. F.

512. *Measurement of Weak Self-Inductions.* **A. Blondel.** (Écl. Électr. 21. pp. 138–141, Oct. 28, 1899. Paper read before the Assoc. française, Boulogne.) —Most of the methods in use are defective in that they require a Wheatstone bridge, the coils of which themselves have both self-induction and capacity. The author utilises the property of torsion electrodynamometers, that if the fixed and the movable coils are respectively traversed by currents similar but differing in phase by ¼ period, the electrodynamic couple is zero. He make the two coils rectangular, one with its longer and the other with its shorte

sides vertical. *Method* 1.—Put the one coil in series with the self-induction to be measured; the other in series with an adjustable standard self-induction; supply the respective coils with currents differing 90° in phase; adjust the standard until there is no deflection in the electrodynamometer and observe the value L_1; the time constants of the two circuits are then equal. Then take out the self-induction which is being measured, and again adjust until there is no deflection in the electrodynamometer: the adjustable self-induction now stands at L_2. Let R be the resistance of each of the coils of the electro-dynamometer, L the self-induction of each—there is no mutual induction—r the resistance of the coil under investigation, r' that of the standard of self-inductance. Then—

$$\frac{L+L_1}{R+r'}=\frac{L+x}{R+r};\quad \frac{L+L_2}{R+r'}=\frac{L}{R};$$

whence the required self-induction of the coil under examination is—

$$\frac{R(r+r')L_2+(R+r)r'L_1}{r'(R+r')}$$

Method 2.—Instead of using an adjustable standard of self-induction, put known resistances in one or other circuit to equalise the time-constants; but in that case the resistances must be dead and be able to carry $\frac{1}{10}$ ampere, so as to keep down the impedance in the electrodynamometer. Put the coil under investigation in one of the circuits: if (using the same symbols as before) $\frac{x}{r}>\frac{L}{R}$, put an additional resistance R′ in the same circuit; if it be less, put this in the other circuit. When, in the former case, the apparatus is brought to zero by adjusting R′, we have—

$$\frac{L+x}{R+r+R'}=\frac{L}{R},$$

whence—

$$x=L\frac{r+R'}{R},$$

and if L be known, x is easily determined. In the latter case

$$\frac{L+x}{R+r}=\frac{L}{R+R'},$$

whence—

$$x=L\frac{r-R'}{R+R'}$$

If the two currents are supplied under equal electromotive forces, the deformation of the curves are similar, and the currents are similar. A. D.

513. *Electric Units.* **A. Blondel.** (Écl. Électr. 21. pp. 7–11, Oct. 7, 1899. Paper read before the Assoc. Franç. at Boulogne.)—Attention is drawn to the grave practical inconveniences arising from the coexistence of the c.g.s. and the practical system of units. The practical units bear varied relations to the c.g.s. units, as this conspectus shows:—

	Multiples of C.G.S. Units.
Microfarad	10^{-15}
Micro-ampere, micro-coulomb	10^{-7}
Microvolt	10^{2}
Watt, Joule	10^{7}
Quadrant, Ohm, Hectowatt, Henry	10^{9}
Megohm	10^{15} &c.

The author, after combating it, now falls in with the suggestion of the American Institution of Electrical Engineers that the systems of units should be based upon the c.g.s. units, and extends it to electrical quantities as well as to magnetic. His present scheme is shown in the following table, in which sufficient terms are entered to show in what manner the various prefixes are used :—

	NAMES OF UNITS.								
	Submultiples.				C.G.S. Units.	Multiples.			
	10^{-15}	10^{-9}	10^{-6}	10^{-3}		10^{3}	10^{6}	10^{9}	10^{15}
Current Strength	Cathogalva	Hypogalva	Microgalva	Milligalva	Galva	Kilogalva	Megagalva	Hypergalva	Anogalva
Potential	...	...	...	...	Frank	...	...	...	...
Resistance	...	...	...	...	Thom	Kilothom	...	Hyperthom	Anothom
Quantity	...	Hypopoisson	...	...	Poisson	...	...	...	...
Power	...	...	...	...	Max	...	...	...	...
Energy	...	...	...	...	Erg	...	Megerg	Hypererg	...
Inductance	...	...	...	...	Helm	...	...	...	...
Capacity	Catharag	...	...	...	Arag	...	...	...	...

Under this system of nomenclature we would say 11 hyperfranks instead of 110 volts, 10 galvas instead of 100 amperes, and we would say hyperthoms instead of ohms and hypermaxes instead of hectowatts. Medical men, instead of 1 to 200 milliamperes, would use currents of from 0·1 to 20 milligalvas. Perhaps the public would find hyperfrank and hyperthom to be rather long words : but some such words would have to be used. The French Association (physical section) approved in principle of the suggestion. A. D.

514. *Contact Electricity.* **F. S. Spiers.** (Phil. Mag. 49. pp. 70–90, Jan., 1900. Paper read before the Physical Society.)—The object of this investigation was to determine the part which the surrounding medium plays in the contact force of metals, special regard being paid to the films of air condensed on the plates. The experiments were carried out in vacuo. The apparatus first employed was constructed on the principle used by Ayrton and Perry in their researches. This, however, was found to be difficult to work with, and was therefore replaced by apparatus in which the plates were magnetically separated for each measurement, the P.D. being measured by Kelvin's compensation method. Heating in high vacua of air merely gave results due to oxidation. The air was therefore replaced by hydrogen, the couple being platinum-aluminium. But the author found that "even in a high vacuum of pure dry hydrogen at the minute pressure of $\frac{1}{10000}$ mm. of mercury, and after four washings in that gas, there is still sufficient oxygen present to completely oxidise the surface of an aluminium plate, if it be only brought to a sufficiently high temperature." It was therefore decided to remove the air films chemically. For this purpose a platinum-iron couple was used. The glass containing-tube was washed out four times with hydrogen, and then heated a number of times to about 800° C. A steady value was not easil obtained, but the final result was that the P.D. fell from + 0·87 to — 0·6 which the author regards as the true value of the volta effect between irc and platinum in an atmosphere of hydrogen. On admitting a small quanti of air the value slowly varied towards a positive value, and on heating accelerate the change it rose to + 0·22. Further heating reduced this figi to zero, owing to oxidation. W. R.

515. *Hissing of the Arc.* **Mrs. Ayrton.** (Instit. Elect. Engin., Journ. 28. pp. 400–430. Discussion 431–450, 1899.)—A change taking place in the electric arc may manifest itself in three ways: (1) By emitting various sounds or by becoming silent; (2) By changes in its electrical measurements; and (3) By an alteration in the appearance of the crater, the arc, and the carbons. The two sounds of the arc which possess significance are the *hum* and the *hiss*. The humming sound is heard when the arc is just on the point of hissing or ceasing to hiss, although it is possible for an arc to jump suddenly from the silent to the hissing state, or *vice versâ*. The paper deals with the arc in this transition stage, viz., from silence to humming and from humming to hissing. No difference in the electrical measurements is noticed whether the arc is silent or humming. The hissing of the arc, which is accompanied by considerable changes, is dealt with more particularly.

Sets of curves are given for direct-current open arcs, showing the variation of the P.D. (between the carbons), with the current strength, for various constant lengths of arc, both silent and hissing. These curves show that :—

1. A silent arc of constant length may be made to hiss by increasing the current strength.

2. A silent arc with constant current may be made to hiss by shortening the arc.

3. When hissing commences the P.D. falls suddenly about 10 volts, and a sudden rise in current also takes place.

4. The largest current that will maintain a silent arc is greater the longer the arc.

5. For the hissing arc, the P.D. is constant for a certain length of arc, whatever the value of the current.

The author proves from the curves of actual experiments that for each pair of carbons the current that will sustain a normal silent arc has a maximum value, and that any current greater than this will make the arc hiss, however long it may be. It is also shown that with the hissing, as with the silent arc, a straight line law connects the P.D. between the carbons with the length of the arc; the difference between the law for silent and for hissing arcs being that with silent arcs the law holds only for constant currents or for currents at the hissing point, whereas with hissing arcs it holds whatever the current may be, since the P.D. between the carbons of a hissing arc is constant for a certain length of arc, irrespective of the current strength. Also from these curves it is shown that the longer the arc the less does the P.D. between the carbons diminish when it changes from silence to hissing.

Experiments were made on the distribution of the fall of pressure in the arc itself, Luggin's results of 1889 being confirmed, viz., that the maximum part of the diminution of P.D. is between the positive carbon and the arc itself. In a hissing arc about two-thirds of the total diminution is accounted for at this point, the remaining third appearing to be due to a lowering of the resistance of the arc itself. The author found that the value of the smallest hissing current depended on the circuit outside the arc, or the sudden increase of current when hissing begins equals the product of the sudden diminution of the P.D. into the conductance of the circuit outside the arc.

The electrical measurements of hissing arcs being dealt with, the author next considers the appearance of the crater, arc, and carbons.

The different changes in appearance are described, from that of a low-current silent arc in which the current is gradually increased to that of a humming and finally a hissing arc. Illustrations are given showing the general shape of the carbons and the distribution of colours in the arc at

these different stages. The most important change in the arc is on the commencement of hissing, when the negative begins to form a "mushroom" at its tip and the crater on the positive more than covers the tip of the carbon. The positive carbon changes to such an extent with different conditions of burning, that it is quite possible to state the conditions under which a normal arc has burnt from the appearance of the positive carbon. The hissing of the arc is caused by air coming in contact with the crater, and is due to the carbon burning instead of volatilising. A silent arc is changed at once into a hissing arc when the flame of the arc leaves the end of the positive carbon and burns on the vertical sides, the air being able to enter the crater itself, thus producing the hissing by causing a part of the heated carbon to burn. This conclusion was arrived at after many experiments. With perfectly enclosed arcs no hissing could be produced; open arcs were made to hiss by having gases introduced into the crater of the arc through a tubular positive carbon. With air or oxygen thus admitted into an open silent arc all the peculiarities of a hissing arc were produced, and also, to a less extent, with hydrogen. With carbon-dioxide or nitrogen no hissing was produced. The same gases, when introduced into the crater of an enclosed arc, produced similar results, with the exception of hydrogen, which produced no hissing. With both open and enclosed arcs no hissing was produced by any of the gases when introduced through the negative carbon gently; but when forced through, hissing was produced and the arc blown out.

Another reason for believing that hissing is caused by access of air to the crater is that the green colour, seen on the outside only of a silent arc, is to be found inside in the case of a hissing arc.

The reading of the paper was followed by a lengthy discussion. E. D. P.

516. *Electrical Instruments.* **W. E. Ayrton.** (Instit. Civ. Engin., Proc. 138. pp. 481–485, Oct., 1899; also Engineer, 87. p. 611.)—The five most important metals employed in the construction of electrical instruments are copper, iron, steel, phosphor-bronze, and some alloy of high resistivity.

For use in central stations or wherever there is a comparatively strong magnetic field, instruments should be used whose action depends upon the motion of a coil in a strong magnetic field so as to eliminate as nearly as possible errors due to variation of field from external causes. Direct reading ohm-meters, measuring up to 50 meghoms, can now be obtained; but apparatus is also needed for enabling the insulation of an electric light cable to be tested where laid. At present cable is often supplied which, although possessing only a fraction of the specified insulation, is accepted because suitable testing apparatus can be used only in a laboratory. W. G. R.

517. *Dynamo-Static Machine.* **E. Thomson.** (Mech. Eng. 4. p. 682, Nov. 4, 1899. Abstract of a Lecture delivered before the New York Electrical Society.)—This machine consists partly of a motor dynamo, such as is obtained by taking an ordinary continuous current motor and tapping the winding so as to obtain alternating currents. To effect thi two of the commutator segments are connected to a pair of insulated met rings on the shaft. The alternating current brushes are connected to th terminals of the primary winding of a step-up transformer. Driven by th shaft of the machine is a frame of insulating material, having at one si a pair of metal strips which periodically connect the high potential seconda terminals of the step-up transformer to the plus and minus coatings of

set of condensers in parallel. These connections, to avoid noise and friction, are made without actual contact; that is, over a small spark-gap. The revolving frame is so adjusted that the charging shall be completed only at the tops of the waves, and then a higher potential is available for charge. The revolving frame carrying the charging strips also carries a set of series connectors, whereby, after the charging strips have withdrawn from proximity to the stationary contacts led from the condenser plates, these contacts are connected in series, and the terminals discharge across a wide air-gap. The length of spark is governed by the number of condenser plates and the potential of the charging current.

The author has added a further attachment whereby Leyden jar batteries may be charged, and with this attachment the machine may be used to excite the sectors of large influence machines in all states of the weather. This attachment consists of a revolving connector covering a wide gap between the terminals or end condenser coatings and a stationary insulating ball or conductor. This connector itself, consisting of a pair of balls or rounded surfaces connected by a wire, is insulated and synchronously bridges the gap of several inches between the end condenser terminal and the insulated ball. The time of making this connection coincides with that of the series connection made by the revolving frame. The insulated ball is thus synchronously charged, while the opposite terminal of the apparatus may be put to earth. The ball may be made either positive or negative by changing the alternating current connections from the collector rings to the primary of the step-up transformer. A Leyden jar battery may be charged by connecting its interior coating with the insulated ball, and its exterior to earth, or to the opposite terminal of the apparatus; and from the charged jar condenser a string, dipped in very weak acid, or rubbed in graphite, may be made the means for conveying the jar charge slowly to a prime conductor for weak or thin sparks, whereby the effects of a static machine may be closely reproduced. W. G. R.

518. *Alternate-Current Curve-Tracer.* **W. Peukert.** (Elektrotechn. Zeitschr. 20. pp. 622–623, Aug. 31, 1899.)—The Joubert contact-disc is not mounted directly on the spindle of the alternator, but is connected to it by means of toothed-wheel gearing, the numbers of teeth in the consecutive wheels (of which there are four) being so chosen that the contact-disc revolves at a somewhat higher speed than the alternator. The arrangement is therefore equivalent to a device (such as that due to Barr, Burnie, and Rodgers) for slowly moving the instantaneous contact-brush, and thus enabling the curve to be traced out in a very short time. A. H.

519. *Current Produced in an Induction Coil by a Parabolic Wave of E.M.F.* **A. Russell.** (Elect. Rev. 45. pp. 744–745, Nov. 10, 1899.)—In this paper the author gives theoretical proofs of the following results:—

(1) If we have a sine wave and a parabolic wave of E.M.F. giving the same effective volts, then the parabolic wave is more flattened than the sine wave. The maximum ordinate of the sine wave is about 8 per cent. higher than the maximum ordinates of the parabola. (2) The ratio of the area of the parabola to the area of the sine curve is 1·014. This also gives the ratio of the maximum values of the choking coil currents. (3) If both waves be applied separately to a non-inductive resistance, the effective currents produced will be equal. If they be applied to an inductive coil

then the current produced by the sine wave will be the greater. If they be applied to a condenser the current produced by the parabolic wave will be the greater. (4) For an inductive coil the power factor is always greater for the sine curve, and the impedance and reactance are both greater for the parabola. (5) The impedance for the parabolic wave is not of the form $\sqrt{R^2 + p^2L^2}$ where p is some function of the frequency. In this case also the angle whose cosine equals the power factor is not in general the angle of time lag of the current curve behind the E.M.F. curve. W. G. R.

520. *Theory of the Power Factor.* **A. Russell.** (Electrician, 44. pp. 49–50, Nov. 3, and 72–73, Nov. 10, 1899.)—The power factor is defined as—

$$\frac{\int_0^T ei\,dt}{\left(\int_0^T e^2dt \int_0^T i^2dt\right)^{\frac{1}{2}}}$$

where e and i denote the instantaneous values of the volts and amperes, t is the time in seconds, and T the period of the alternating current. The author shows that the power factor is not necessarily unity if the values of e and i are always simultaneously zero, but that its value depends upon their wave forms. Taking the current wave to be a sine curve, numerical values of the power factor are calculated for various forms of the E.M.F. wave; these results are tabulated thus:—

Wave Form of E.M.F. curve.	Maximum value of e.	Height of Centre of Gravity of Wave.	Power Factor $\cos\phi$, with I $\sin pt$ for Current.	ϕ in Degrees.	Power Factor with I $\sin(pt-\alpha)$ for Current.
Rectangle..........	V	0·5 V	0·9003	25·8	0·9003 $\cos\alpha$
Parabola	1·370 V	0·5476 V	0·9995	2·2	0·9995 $\cos\alpha$
Sine Curve	1·414 V	0·5552 V	1·0000	0	$\cos\alpha$
Triangle	1·732 V	0·5773 V	0·9928	6·75	0·9928 $\cos\alpha$
Inverted Parabola	2·236 V	0·6708 V	0·9322	21·2	0·9322 $\cos\alpha$
Inverted Cubics ...	2·646 V	0·7560 V	0·8628	30·4	0·8628 $\cos\alpha$

Thus if $\cos\phi$ is the power factor when α is zero, $\cos\phi\cos\alpha$ is its value for any given value of α. The paper is summarised as follows:—

1. If the power factor of a circuit is unity, then the potential difference and current waves are similar curves, *i.e.*, the value of the volts divided by the value of the amperes at any instant is constant.

2. If the potential difference wave be flat and the current wave peaked or *vice versâ*, then the power factor may be small, even if there be no time lag between them.

3. It is convenient for graphical purposes to define the phase differen

between two periodic functions, $f(t)$ and $F(t)$, as an angle ϕ given by the equation—

$$\cos\phi = \frac{\int_0^T f(t)F(t)dt}{\left(\int_0^T \{f(t)\}^2 dt \int_0^T \{F(t)\}^2 dt\right)^{\frac{1}{2}}}$$

4. If either the current or potential difference wave is a sine curve, and the other is a symmetrical curve, then the power factor equals $\cos\phi\cos\alpha$, where $\cos\phi$ is the power factor between them when there is no time lag and α is the angle of time lag. W. G. R.

521. *Half-Ring Electromagnet.* **H. du Bois.** (Ann. d. Physik, 1. 1. pp. 199–206, Jan., 1900.)—The ring-electromagnet described by the author yields a field of some 40,000 units over a space of several millimetres. By using micromagnetic appliances with dimensions of the order of 0·1 mm., the values 51,600 for H and 74,200 for B were obtained. But the whole apparatus weighs 5 cwt. and uses 5 kw. The author has therefore constructed a lighter type, by reducing the linear dimensions 20 per cent. and cutting off the lower third of the ring, which is replaced by a bedplate. Excitation is made by eight magnetising coils, with an interval between the highest and the second on each side, which allows the observer to remove two plugs running along the magnetic axis, and thus expose the axis for polarisation and other experiments. The power consumed in this type is 1·44 kw. In another type, which is still smaller, the power consumed is 256 volts, the weight is 25 kgm., the height of the axis above the table is 25 cm., the number of turns 2,000, the resistance 4 ohms, and the inductance 60 henries. The efficiency of these half-ring electromagnets is, if anything, greater than that of the whole-ring instrument, the field furnished by the heavier type being 36,000 units, and by the lighter type 20,000 units. E. E. F.

522. *Magnetic Properties of the Elements.* **J. Koenigsberger.** (Ann. d. Physik, 1. 1. pp. 175–177, Jan., 1900.)—The author considers it as definitely proved that a compound formed of two diamagnetic substances may be itself paramagnetic, and instances the cases of cuprous sulphide, selenide, and phosphide. A connection can be traced between atomic magnetism and atomic volume, but this connection is complicated by the anomalous position of tin. The author regards the magnetic susceptibility of water as undetermined as yet, and thus throws a doubt on all data obtained from aqueous solutions. Wire-drawing has a well-marked effect upon the magnetic susceptibility of a metal in certain directions. E. E. F.

523. *Molecular Magnetic Susceptibilities.* **O. Liebknecht** and **A. P. Wills.** (Ann. d. Physik, 1. 1. pp. 178–188, Jan., 1900.) **H. du Bois** and **O. Liebknecht.** (Ann. d. Physik, 1. 1. pp. 189–198, Jan., 1900.)—The first paper deals with the magnetic susceptibilities of paramagnetic salts of the iron group, including haloids, sulphates, nitrates, and alums, of chromium, manganese, iron, cobalt, nickel, and copper. The susceptibilities show an increase from chromium to manganese, and a subsequent gradual fall from ferric iron to cobalt, nickel, and copper. Jäger and Meyer's series of atomic magnetisms 6 : 5 : 4 : 2 for Mn, Fe, Co, *Ni, respectively* is only very roughly

confirmed, but some of the discrepancies may possibly be due to the nickel salts containing some cobalt.

In the second paper the molecular susceptibilities of several rare earths are studied, including those of yttrium, cerium, praseodymium, neodymium, samarium, gadolinium, erbium, and ytterbium, all of Swedish preparation. In contradistinction to the iron group of elements, there is here a gradual rise of susceptibilities from the beginning of the series to erbium, and a sudden fall to ytterbium, the two last values being 0·03668 and 0·00711 respectiv ly. Among important substances yet to be tested are titanium, vanadiun nd perhaps thorium ; and molybdenum, tungsten, and uranium in the iron group. The difficulty encountered in these metals is that they do not form paramagnetic compounds. The authors consider the determination of susceptibilities in the wet way as both simple and accurate. E. E. F.

524. *Magnetic After-effect.* **L. R. Laird.** (Ann. d. Physik, 1. 1. pp. 207–218, Jan., 1900.)—In experiments on magnetic viscosity a doubt attaches to the initial or instantaneous value of the magnetisation. This doubt is eliminated in the method of Martens, in which horizontal discs are made to rotate in a magnetic field. Their magnetic moment is found to be independent of the speed of rotation within wide limits, and is therefore identical with the instantaneous value itself. The after-effect is then determined by the increase experienced when the disc stops. To study the increase of moment with the time the author used an astatic system with one of its needles placed near the edge of the disc, and in the plane of the latter. The ratio of the initial to the final intensity of magnetisation was found to be 0·872 in the disc used, which was of rolled iron, 0·062 cm. thick, 4·5 cm. in diameter, and repeatedly annealed. To follow the course of the after-effect in time a photographic method was used. The effect was completed in twelve seconds. E. E. F.

525. *Plane Magnetisation of Pyrrhotine.* **P. Weiss.** (Journ. de Physique, 8. pp. 542–544, Oct., 1899.)—This mineral, Fe_7S_8, can be magnetised only in one plane, and in a direction at right angles to this plane there can be no magnetisation. Discussion of experimental methods. This curious property may throw some light on the behaviour of magnetic metals, considered as crystalline substances. (See also 1899, Abstract No. 718.) A. D.

526. *Altitude and Terrestrial Magnetic Force.* **A. Pochettino.** (Accad. Lincei Atti, 8. pp. 204–212, Oct. 15, 1899.)—The author finds (at Gran Sasso, Italy) that the gradient of H is 0·0005 c.g.s. units per thousand metres of ascent. A. D.

REFERENCES.

527. *Electrothermal Relations.* **F. Kohlrausch.** (Ann. d. Physik, 1. 1. pp. 132–158, Jan., 1900.)—A paper similar to that referred to in Abstract No. 136 (1900). E. E. F.

528. *Thermoelectricity.* **L. Holborn** and **A. Day.** (Preuss. Akad. Wi Berlin, S. ber., 36. pp. 691–695, 1899.)—Measurements were made of the therm electric constants of the platinum metals and gold and silver over a large range temperature. The hot junctions were raised to 1,000° and in some cases to 1,80 The results are given in a table. Observations were also made at lower tempe tures down to −185°. J. J

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529. *Adsorption.* **J. G. C. Vriens.** (Zeitschr. Phys. Chem. 31. pp. 280–284, Dec. 22, 1899.)—The adsorption taking place when a centinormal solution of nitric acid is passed through a number of filter papers is measured by determining the molecular conductivity of the liquid before and after filtration. The author concludes that the diminution of concentration is proportional to the number of filters employed. T. H. P.

530. *Liquid Air.* **J. Dewar.** (Roy. Instit., Proc. 16. pp. 815–829, Aug., 1899.)—Liquid air assumes the spheroidal state when poured into a silver basin heated to redness. When a gas is caused to condense in a bulb, cooled by liquid air boiling in a vacuum, an admixture of an uncondensable gas which is not readily soluble in the condensed liquid may be detected. One part of hydrogen in 1,000 of air can just be detected in this way. Helium is readily separated from the gas (mainly nitrogen) evolved from the King's Well at Bath by this method.

At the temperature of liquid air argon is more opaque to Röntgen rays than oxygen, nitrogen, or sodium; it is on a level with potassium, chlorine, phosphorus, aluminium, and sulphur. This suggests that its atomic weight is comparable with those of the latter group of elements.

A large number of comparisons of the times in which equal quantities of liquid air evaporate from different vacuum test tubes were made. When the annular space is (1) filled with air, (2) vacuous, (3) vacuous and silvered inside, the times of evaporation are approximately as 1 : 5 : 30. When the annular space is (1) vacuous, (2) vacuous and filled with lampblack, the times are as 1 : 4. Other powders have a similar (usually smaller) effect. When air is admitted, however, the tubes containing the powders are less efficient than those without them.

At the temperature of liquid air a photographic film was six times less sensitive to ordinary and Röntgen radiation and sixteen times less sensitive to ultra-violet light than at the ordinary temperature. T. E.

531. *Properties of Iron.* **Galy-Aché.** (Comptes Rendus, 129. pp. 1230–1232, Dec. 26, 1899.)—To explain the peculiar phenomena of the tempering of steel, Osmond and Werth put forward the hypothesis of the existence of two allotropic forms of iron: α-iron, stable at ordinary temperatures, and β-iron, stable at high temperatures. The author describes some experiments which go to confirm this view. Some of them recall the familiar facts of recalescence, while others show that recalescence is accompanied by a certain retardation in the compression, which depends greatly upon the manner in which the iron is cooled down from temperatures above 850°. The iron experimented upon was nearly pure and quite free from carbon, though it contained traces of phosphorus. If this iron is subjected to a pressure of 18 kg. per square mm. it shows a certain permanent compression. When released and then subjected to the same pressure, no further compression sets in until the previous maximum pressure is attained. When the release has lasted several hours, the specimen will support a much higher pressure than that previously attained without giving way. Sudden cooling after heating to 850° eliminates the properties described. E. E. F.

532. *Alloys of Iron and Nickel.* **F. Osmond.** (Instit. Civ. Engin., Proc. 138. pp. 312–327, Oct., 1899.)—The positions of the critical points Ar_1, Ar_2, Ar_3 are observed both by heating and by cooling alloys of nickel and iron containing up to about 50 per cent. of nickel. The critical points are depressed by the addition of nickel, but the changes to which these points are due are not reversible in nickel steels containing less than 25 per cent. of nickel, the changes occurring at a higher temperature during heating than during cooling. The divergence increases with the percentage of nickel. With 3·82 per cent. of nickel the points Ar_3 and Ar_2 (cooling curve) merge into one, and, when the percentage of nickel has reached about 15, Ar_1 either disappears or merges into the point Ar_{3-2}. The heating curve has only one critical point between 7·65 and 24·5 per cent. of nickel. Steels containing less nickel have two critical points, one corresponding to Ac_3, the other to Ac_1 and Ac_2. Alloys with 29·07 and 49·65 per cent. of nickel showed no critical point.

The temperatures at which the magnetism of the alloys appears and disappears are determined (see 1899, Abstract 1203); these temperatures coincide with the points Ar_2 and Ac_2 respectively.

The total magnetism decreases as the percentage of nickel increases, becoming zero at about 29 per cent. of nickel; it then increases again. The residual magnetism, starting at zero in pure iron, increases to a maximum at 15·48 per cent. of nickel, and then decreases to zero at 29 per cent. of nickel. For the alloys containing more than 29 per cent. of nickel it is very small. The alloys with 14 to 15 per cent. of nickel remain hard after cooling from temperatures above the point Ac_{3-2} (610° to 620°), but are softened by heating to temperatures below this. The permanent magnetism of such alloys is shown to increase with the hardness, and to afford a ready method of following the effects of the thermal treatment.

The microstructure of nickel steels is investigated. (See 1898, Abstract No. 1071.) T. E.

533. *Heat of Formation of Alloys.* (Electrician, 43. pp. 883–884, Oct. 13, 1899. Report of Brit. Assoc. Committee.)—Experiments were made on 22 different alloys of zinc and copper. To obtain the heat of formation, the heat of solution of the alloy was found and compared with the heat of solution of the constituents. The differences indicate that the heat of formation is at first negative, and reaches a maximum at 16 per cent. of copper. With greater percentages of copper it becomes positive, reaching a maximum at 38 per cent. of copper. Beyond this point it again grows less, being almost zero at 90 per cent. of copper. Curves and a table of results are given.

W. R. C.

534. *Heat of Dilution of Solutions.* **O. Tumlirz.** (Akad. Wiss. Wien., S. ber. 108. pp. 323–340, 1899.)—Thomsen's theory is inadequate. The author works out the subject from the point of view of the mathematical theory of attraction, and finds the energy of a mixture of two liquids—A and B—to undergo three alterations upon admixture. (1) The liquid A assumes a new volume V′, that of the mixture, and its own energy varies accordingly. (2) The same for liquid B. (3) The energy due to the mutual attractions between A and B has to be accounted for. The result is the establishment of a formula—

$$W = \frac{an + bc + cen}{V'},$$

where W is the energy (heat) liberated or absorbed, a, b, and c are constants, n is the ratio between the masses of the diluent and the diluted liquid, e is the difference between the original volumes and the final volume, and V′ the final volume. In the case of sulphuric acid and water, $a = 159{\cdot}40$, $b = 222{\cdot}55$, and $c = 73{\cdot}84$. In the case of acetic acid, $a = -44{\cdot}00$, $b = 122$, $c = 505$; so that on adding water progressively to acetic acid there is first cooling and then the evolution of heat. A. D.

535. *Ozonised Water.* **E. Andréoli.** (Électricien, 18. pp. 302–304, Nov. 4, 1899.)—The author first discusses the writings of various authorities on the solubility of ozone in water or solutions of mineral acids and salts. He points out that solution is best effected by bubbling ozone in a finely divided stream into the liquid (see 1889, Abstract No. 1949). The solubility under the best circumstances is slight, and in no case does the solution remain, as the amount of ozone present becomes rapidly less and then disappears, leaving no trace either when analysed or to the nose.

The same is found when dry ozone is kept in a closed glass receptacle. The value of ozone as a bactericide in the case of tuberculosis is pointed out, but a warning is given against a number of high-priced quack preparations which are said to contain ozone, but which are merely very dilute solutions of alkaline hypochlorites. The discovery of a real means of preserving ozone in a form in which it could be utilised as a medicine is pointed out as being probably of great value. J. L. F. V.

536. *Explosion of Potassium Chlorate.* **Berthelot.** (Comptes Rendus, 129. pp. 926–929, Dec. 4, 1899.)—Potassium chlorate is an endothermic compound, as indicated by the equation $KClO_3 = KCl + 3O + 11{\cdot}9$ Cal., but it is not usually classed among explosive substances. If, however, the salt is very suddenly heated to a temperature above that at which it begins to decompose, as by dropping a small portion of the fused salt into a red-hot glass tube, a sharp, though slightly prolonged, detonation is observed. Picric acid, as the author has previously shown, behaves in a similar manner, and analogous phenomena are observed with acetylene. In each case the velocity of combination or decomposition continues to increase, provided the conditions are such that the rise in temperature is not checked by dissociation, change of physical state, &c. The detonation of potassium chlorate is more violent when combustible substances are also present, as was the case in the recent explosion at St. Helens. N. L.

537. *Action of the Medium on Velocity of Reaction.* **A. de Hemptinne.** (Zeitschr. Phys. Chem. 31. pp. 35–41, Dec. 22, 1899.)—The author determines velocity constants for the saponification of methyl acetate by mixtures of hydrochloric acid and acetone of varying composition, the electrical conductivity of the different mixtures being also determined. As the proportion of hydrochloric acid used decreases, the velocity constant and the conductivity also decrease, but not to the same degree, the ratio of speed to conductivity showing a considerable increase. Thus, besides the ionic action, the solvent exerts an action on the saponification velocity which in the case of acetone is catalytic, acetone having no chemical action either on methyl acetate or its saponification products. Using mixtures of glycerine and hydrochloric acid and of glycerine and sulphuric acid, no constant numbers are obtained for the saponification velocity of methyl acetate; the action of the glycerine in promoting the splitting up of methyl acetate depends on the slight affinity it

538. *Velocity of Crystallisation and of Change in Heterogeneous Systems.* **M. Wildermann.** (Zeitschr. Phys. Chem. 30. pp. 341–382, Nov. 1, 1899.)—Details of the experiments from which the equation $dt/dz = C(t_0 - t)(t - t_1 + K)$ [Abstract 1393, 1899] is obtained are given. The application of this equation to chemical and physical change in heterogeneous systems is discussed.
T. E.

539. *Solid Solutions and Isomorphous Mixtures.* **G. Bruni.** (Accad. Lincei Atti, 8. pp. 212–219, Oct. 15, 1899.)—Isomorphous mixtures are in all respects merely special cases of solid mixtures. Conclusions to the contrary, by Küster, Bodländer, and others are discussed. A. D.

540. *Coagulative Power of Electrolytes.* **W. C. D. Whetham.** (Phil. Mag. 48. pp. 474–477, Nov., 1899.)—Electrolytes possess the property of coagulating solutions of colloids such as albumen and As_2S_3, and their relative coagulative powers depend on the valency of the metallic ion. The coagulative power of a substance may be taken to be inversely proportional to the number of gramme-equivalents which must be added to a definite solution of the colloid in order that immediate coagulation should follow. Linder and Picton found equi-coagulative solutions of sulphates of mono-, di-, and tri-valent ions, acting on arsenious sulphide, to bear the relative concentrations 930, 26, 0·9, so that the relative coagulative powers would be in the ratios 1 : 35 : 1023. For chlorides Schultze found similar ratios 1 : 30 : 1650. Suppose that, in order to cause coagulation, a certain minimum electrical charge has to be brought within reach of a colloidal group, and that such conjunctions must occur with a certain minimum frequency throughout the solution. To bring up such equal charges we must have the conjunction of $2n$ triads, $3n$ dyads, or $6n$ monads. The chance of an ion being within reach of a fixed point is a fraction, Ac, where A is a constant and c the concentration; that of two ions is $(Ac)^2$; that of three is $(Ac)^3$; that of n is $(Ac)^n$. For equi-coagulative powers the frequency with which the necessary conjunctions occur must be the same in each solution; and for triads, dyads, and monads respectively $A^{2n}c_3^{2n} = A^{3n}c_2^{3n} = A^{6n}c_1^{6n} =$ a constant $= B$, whence the respective concentrations necessary for equal coagulative powers are $c_1 : c_2 : c_3 = 1 : x^{-1} : x^{-2}$, where $x^{-1} = B^{1/6n}$. The coagulative powers of monad, dyad, and triad metal ions are therefore in the ratios $1 : x : x^2$. If $x = 32$ this gives the series 1 : 32 : 1024 to compare with Linder & Picton's 1 : 35 : 1023 : if $x = 40$ we get 1 : 40 : 1600 to compare with Schultze's 1 : 30 : 1650. By parity of reasoning, tetravalent elements would have very large coagulative powers. A. D.

541. *Effect of Salts on the Strength of Acids.* **S. Arrhenius.** (Zeitschr. Phys. Chem. 31. pp. 197–229, Dec. 22, 1899.)—The author determines the effect produced on the rates of inversion of cane sugar by acetic, formic, or phosphoric acid by the addition to them of varying quantities of the following salts: potassium chloride, chlorate or nitrate, sodium chloride, bromide or nitrate; the greatest concentration of the salt solution employed being 0·125 normal. The results show that the relative increase (z) of the inversion velocity is nearly proportional to the square root of the quantity (c) of salt present. Thus, if c and z are the values for one salt solution, and c' and z' for another, the numbers for 0·05 normal acetic acid and sodium chloride giv $\log z/z' : \log c/c' = 0{\cdot}548$, the corresponding ratio for 0·025 normal acetic aci and potassium nitrate, chloride or chlorate or sodium nitrate, having the valu

. Taking into account the dissociation of the acids, it is seen that as th

concentration of hydrogen ions in the solution increases, the value (x) of the above ratio shows a continuous increase, z at the same time gradually decreasing. Whilst the sugar-content of the solution has no appreciable influence on the value of x, the temperature on the other hand produces a very marked effect.

The changes caused in the reaction velocities of weak acids by the addition of salts, as determined in this way, are complicated by three disturbing factors for which corrections are made: (1) The action of the neutral salt itself in producing sugar inversion; (2) A slight chemical action between the acid and the added salt: (3) The action of the salt in increasing the dissociation constant of the acid; corresponding to this a similar increase is obtained in the dissociation constant of a salt solution as the concentration increases, and in both cases the increase obeys the same law. Ostwald's dilution law, in all probability, does not hold exactly for any electrolyte; in the case of weak acids and bases the deviations lie within the limits of experimental error, but these deviations increase with the dissociation constant and have their greatest values for the most strongly dissociated bodies, viz., salts, and strong acids and bases.

A series of experiments made with solutions of varying strengths of the mixtures, KCl and NH_4Cl, KNO_3 and $KClO_3$, and KNO_3 and $NaNO_3$, shows that the conductivity of a mixture of two salt solutions of equivalent strengths is equal to the mean of the conductivities of the separate solutions, the ionic concentration being unchanged by the mixing. Calculations made according to Noyes' view—that the dissociation factor depends only on the concentration of the non-dissociated part of the dissolved salt—do not agree with the observed numbers. In apparent contradiction with these experiments is the diminution in the solubility of a slightly soluble salt effected by the addition of one of its ions to the solution; in this case it is assumed that the solubility of the non-dissociated portion of the dissolved salt remains constant. From the results of experiments on the sodium and silver salts of valeric, monochloracetic, butyric, propionic, and acetic acids, the author concludes that this assumption is erroneous, as the solubility of the non-dissociated silver salt decreases very considerably when the corresponding sodium salt is present. Similar behaviour is exhibited by the solubility in water of potassium hydrogen tartrate when methyl or ethyl alcohol, cane sugar or glycerine is added to the solution.

T. H. P.

542. *Heats of Fractional Neutralisation of Hydroferrocyanic and Hydroferrocarbonylcyanic Acids.* **J. A. Muller.** (Comptes Rendus, 129. pp. 962–964, Dec. 4, 1899.)—The author finds for each gramme atom of hydrogen neutralised in the acids $H_4Fe(CN)_6$ and $H_3FeCO(CN)_5$ the same value for the heat-evolution, viz., 14 Cal. The solutions were dilute, the temperature about 18·6° C., and the bases employed, potassium and Barium hydrates. The conclusion is that these acids are both *strong*, or, expressed in modern language, that they are nearly completely dissociated in dilute solution. F. G. D.

543. *Thermochemical Study of Narcein.* **É. Leroy.** (Comptes Rendus, 129. pp. 1259–1261, Dec. 26, 1899.)—The author's experiments were made with a sample containing *two* molecules of water of crystallisation. When dissolved in boiling water and recrystallised by cooling, the ordinary hydrate with *three* molecules of water of crystallisation was obtained. Determinations were made of: (1) The heat of hydration (by dissolving the anhydrous base

and therefore the heat of formation from the elements; (3) Heats of formation and hydration of the hydrochloride; (4) Heat of formation of the potassium salt in dilute solution.

Reference must be made to the original paper for the figures. The author concludes that narcein is a very feeble base, in fact the weakest of the opium alkaloids. It possesses an electrolytically dissociable hydrogen atom, and so acts as an acid. In this respect, however, the heat of formation of the potassium salt, although greater than that of the phenates, is considerably less than that evolved in the formation of such salts as acetates, benzoates, &c.

F. G. D.

544. *Influence of the Solvent on the Cryoscopic Behaviour of Phenols.* **K. Auwers** (with **H. M. Smith** and **W. Bartsch**). (Zeitschr. Phys. Chem. 30. pp. 300–340, Nov. 1, 1899.)—The abnormal cryoscopic behaviour of certain phenols, which has been shown—Zeitschr. 18.595 (1895); 21.337 (1896); 23.449 (1897)—to depend in a regular way upon their constitution, cannot be satisfactorily explained by the assumption that association takes place, since the effect of dilution on the cryoscopic values does not correspond with the laws of dissociation, and moreover the association factors in solution would require to be much greater than those observed by Ramsay and Shields in the case of liquids. The extent of the deviations does not depend in any regular way upon the freezing-point of the solvent or the magnitude of its depression constant; thus in the case of p-dichlorobenzene and p-nitrotoluene, which have nearly the same melting-point (53° and 52°) and depression constant (77 and 78), the deviations in the apparent molecular weight of p-hydroxybenzaldehyde are 400 and 39 per cent. respectively; it is, however, influenced in a regular way by the constitution of the solvent. The deviations are greatest in p-dichlorobenzene, p-chlorobromobenzene, and p-dibromobenzene, and are much less marked in the nitro-derivatives of benzene and toluene; in the case of the three di-halogen-benzenes a regular gradation is observed in the apparent molecular weights of all the substituted phenols examined. For solutions of p-nitrophenol in nitrobenzene, p-chloronitrobenzene, p-nitrotoluene, and m-dinitrobenzene, the deviations in the apparent molecular weight are almost independent of the concentration; this is explained by the formation of solid solutions, owing to the similarity in structure of the solvent and solute. T. M. L.

545. *Potential between Metals and Non-Aqueous Solutions.* **L. Kahlenberg.** (Journ. Phys. Chem. 3. pp. 379–403, 1899.)—Eighty-nine results are given for metals immersed in non-aqueous solution of salts. In the case of solutions containing the same quantity of salt per litre, the P.D. appears to depend upon the nature of the solvent: solvents of a similar chemical nature give results which are nearly the same. As a rule, the electrolytic solution pressure of the metals for these various solutions cannot be calculated for lack of data. The conductivity is usually low, giving no limiting value, and cryoscopic methods are not sufficiently sensitive. It has also been found that high conductivity may be accompanied by normal molecular weight. Many contradictory results are found, from which it appears that if the osmotic pressure theory be true the solution tension must vary with the solvent. W. R. C.

546. *Reflecting Power of Electro-Deposited Metals.* **S. Cowper-Coles.** (Electrician, 44. p. 267, Dec. 15, 1899.)—Silver was deposited on glass and backed with copper, the deposit then separated from the glass, and the silver coated

with the respective metal. The tests were made with the help of a Bunsen photometer and pentane standard lamps. If the reflecting power of silver is 100, chromium is 100, platinum 74, palladium 64; for chemical rays and astro-photography platinum and palladium appear, however, superior to silver. Silver is, moreover, soon tarnished in proximity to an arc lamp, whilst palladium keeps its reflecting power. Nickel is unsuitable for arc lamps. When a polished brass plate is silvered, and then thinly gilded and finished, and finally coated with a very thin film of palladium, the reflecting powers are: gold 77, palladium 68, *i.e.*, almost the full value for palladium, although the gold could distinctly be seen through it. The angles of incidence are not stated. As to the electro-deposition of palladium, see Abstract No. 1749 (1899).

H. B.

547. *Electrolytic Trees of Copper.* **S. Cowper-Coles.** (Electrician, 44. pp. 288–289, Dec. 22, 1899.)—The author describes the results of experiments made with a view to determine the effects of variation in the current density, in the strength, acidity, and temperature of the electrolyte, and in the shape of the kathode, upon the formation of the irregular deposits known as trees or nodules. A current density of 60–70 amperes per square foot was found to be most favourable to "treeing." No other definite conclusions are given. Six photographs of deposits obtained in these experiments are reproduced.

J. B. C. K.

548. *Electrolytic Deposition of Zinc under Pressure.* **S. Cowper-Coles.** (Electrician, 44. p. 183, Dec. 1, 1899.)—The experiments described by the author in this brief note were undertaken in order to find the effect of pressure upon the cohesion and other physical properties of the deposited zinc. Mild steel plates were used as kathodes, with lead or zinc as anodes. The electrolyte was a solution of zinc sulphate containing free acid and zinc dust. A pressure of one ton per square inch was maintained in the cell during electrolysis. Current densities varying between 17 and 100 amperes per square foot were used. The best results were obtained with a current density of 50 amperes, but no details of the cohesive or other physical properties of the deposit are given. Three photographs of the deposits obtained are reproduced.

J. B. C. K.

549. *Great Falls and Anaconda Copper Refineries.* (Electrician, 44. pp. 251–254, Dec. 15, 1899.)—A description of the electrical generating machinery at the Great Falls Refinery of the Boston and Montana Company, and at the Anaconda Refinery, Montana.

The first is driven by water-power, the second by steam-power. The head of water at Great Falls is 50 feet. A 2,900 H.P. twin-turbine drives two Westinghouse generators, each rated at 810 kw., but regularly driven to yield 1,210 kw. The current supplied by each of these dynamos is 5,500 amperes, at 220 volts pressure. Details of the construction and views of these large dynamos are given. The copper conductor used for conveying the current from the generating house to the depositing tanks is 12 inches wide, 2 inches thick, and half a mile in length. The anodes are pigs of raw copper, 24 inches square and 2 inches thick; they are cast with projecting bars to facilitate hanging in the vats. The 1898 Report of the Boston and Montana Company shows that the sales of copper, silver, and gold were valued at £1,500,000, and that profits equal to £700,000 were made.

The generating machinery at the Anaconda Refinery is likewise of

Westinghouse construction. The units are, however, much smaller than at Great Falls, and are as follows: Three 270-kw. dynamos, belt-driven; four 270-kw. dynamos, direct coupled; two 360-kw. dynamos, direct coupled. Some details of the commutator construction of these machines are given.

J. B. C. K.

550. *Aluminium.* **J. H. Henderson.** (Indus. and Iron, 27. p. 395, Dec. 15, 1899. Abstract of a paper read before Manchester Junior Elect. Engineers, Nov. 28, 1899.)—This Abstract gives some details concerning the electrolytic method of producing aluminium from the oxide, and a few facts relative to the use of the metal for electrical purposes, and to the precautions necessary in casting and when working it in the lathe.

The composition of the molten bath used for dissolving the dry alumina is given as: Fluoride of calcium, 234 parts; double fluoride of cryolite [? cryolite itself], 421 parts; fluoride of aluminium, 845 parts; calcium chloride, 3 to 4 per cent.

This bath is heated to 1,210° F., alumina is added, and the electrolytic decomposition is carried out with an E.M.F. of 6–8 volts and a current density of 216 amperes per square foot. One pound of the metal should be obtained per 5 E.H.P. hours.

J. B. C. K.

551. *Electrolytic Production of Aluminium.* **G. H. Robertson.** (Electrician, 44. pp. 287–288, Dec. 22, 1899.)—The author in this short article gives some historical details relating to the electrolytic processes for reducing aluminium oxide, and then passes on to a description of those processes in which the sulphide is substituted for the oxide. The latest of these is the Gooch process, in which the sulphide is formed from the oxide in the electrolytic bath itself by chemical action.

In this process the solvent for the oxide is a fused mixture of sodium fluoride and aluminium chloride. The anodes are of carbon; the carbon lining of the bath acts as kathode. The anodes are perforated longitudinally, and the carbon disulphide is conducted into the bath as vapour through these perforated anodes. The bath is fed with alumina, and the sulphur, carbon monoxide, and carbon oxy-sulphide which result from the electrolytic and chemical decompositions pass away as gases. The E.M.F. required for the decomposition is said to be only 0·90 volt.

J. B. C. K.

REFERENCES.

552. *Primary Batteries.* **W. R. Cooper.** (Electrician, 44. pp. 226–228, Dec. 8, 1899.)—Seat of the E.M.F. in a voltaic cell.

553. *Electrochemical Industry.* **W. Borchers.** (Eng. Mag. 18. pp. 389–402, Dec., 1899.)—This article is a presentation in more popular form of the facts and figures contained in the paper read before the 1899 meeting of the German Electro-chemical Society at Leipzig. (See 1899, Abstract No. 1947.) After an introduction describing the various forms in which energy is found upon this earth, the author states that the use of the potential energy of the coal-beds is about to be exchanged for the use of the kinetic energy of moving or falling water. Very brief descriptions of the processes and apparatus used in all the chief electrochemical and electro metallurgical industries are then given, and the author concludes by pointing out that 90 per cent. of the estimated output of these new works and factories is due the utilisation of water-power.

J. B. C.

554. *Cost of Calcium Carbide.* (Engineer, 88. pp. 611–612, Dec. 22, 1899.)

STEAM PLANT, GAS AND OIL ENGINES.

555. *Mechanical Draught and Boiler Efficiency.* **W. B. Snow.** (West. Electn. 25. pp. 74–75, Aug. 5, 1899. Extract from lecture delivered before the Engineering Society of Columbia University.)—Estimates are given of the relative costs and fixed charges for boiler plants having chimney draught, and induced and forced draught without chimneys. An average of the costs of nine representative plants shows the total expense for installing a forced draught plant to be only 18·7 per cent.; that of a single induced fan and accessories 26·7 per cent., and that of a complete duplex induced draught plant, 42 per cent. of that of a chimney. In each case a short steel-plate stack is included.

J. T. R.

556. *Internal Self-oiling Ball Engine.* (West. Electn. 25. p. 88. 1899.)—The distinctive feature of the new design of the Ball engine is the automatic oiling system. The oil is contained in a pocket in the bottom of the crank chamber, and the crank discs in revolving carry over a portion of this oil into a trough in the top of the frame, from which the oil flows to the main bearings and is carried by radial holes to the crank-pin. There are removable plates one on each side of the connecting-rod at the ends of the guides, so arranged that they guide the oil directly into the crosshead. The lower guides are so designed that the crosshead floats on the oil, and the area of the slides being large the wear is practically eliminated. The oiling is claimed to be automatic, positive, and requiring no attention. The Company supply self-oiling engines, simple, tandem, cross-compound, and either side-crank or centre-crank as desired. A. S.

557. *Feed Water Heaters for Locomotives.* **C. M. Muchnick.** (Mech. Eng. 4. pp. 637–638, Oct. 28, 1899. From the American Engineer and Railroad Journal, Oct., 1899.)—The author describes two feed water heaters for locomotives, used on the Paris-Orleans Railway and the Western Railway of France respectively. Lencauchez, engineer of the Paris-Orleans Railway, designed a heater combined with an oil separator. The exhaust steam taken from each cylinder is led into an oil separator formed of a number of hollowed-out plates, assembled in such a manner that the steam has to make several up-and-down courses, leaving the oil on the hollowed-out portions of the plates. The steam thus purified passes into the heater proper, where it comes in contact with the cold water which falls, fountain-like, over a series of trays, each having a finely divided toothed edge. The division of the cold feed water into very small streamlets facilitates the rapid mixture of the cold water and steam. A pump then forces the feed water into the boiler at a temperature of 192–208° F. The feed heater is provided with check valve, safety valve, and gauge glass.

In the feed water heater designed by Chapsal, engineer of the Western Railway of France, the cold feed water passes over a series of cones in which steam circulates. Thin deposits from the impure feed water are formed on the surface of the cone, and when broken by the contraction of the latter accumulate around the bottom edges of the cones. It was found that the deposits of laminated tartar when weighed in a dry state varied from 22 lbs. to 44 lbs. for a running distance of 1,875–8,750 miles. A. S.

558. *Hydraulic Boiler Test.* (Mech. Eng. 4. p. 623, Oct. 28, 1899. From Proc. of the American Boiler Manufacturers' Association, "Power.")—The boiler was a cylindrical multitubular shell boiler, made of steel plates ¾ inch thick, the steel having a tensile strength of 55,000 lbs. Size of boiler, 5 feet diameter and 14 feet long. Tubes of steel, 50 in number, and 3½ inches diameter. The shell was divided into three rings, A, B and C, the circumference of each containing two plates. The vertical or circumferential ring seams were single-riveted lap-joints; the transverse or horizontal seams were as follows: In ring A, on one side of the boiler a triple-riveted lap-joint with inside covering strap, and on the other side a quadruple-riveted butt-joint with outside and inside straps. In ring B, a triple-riveted lap-joint, same as in A, and a triple-riveted butt-joint with inside and outside straps. In ring C, a triple-riveted butt-joint, and a quadruple-riveted butt-joint, both having inside and outside straps.

Under a pressure of 450 lbs. per square inch, the shell became ⅛ inch shorter than normal size, whilst the circumference at the centre of the rings measured as follows: At A, 1/16 inch longer; at B, ⅜ inch longer; at C, ¼ inch longer, the boiler remaining tight. At 650 lbs. pressure the boiler became ⅜ inch shorter, at ring A the circumference increased to 2¼ inches above normal size, at B 3⅜ inches, and at C 2¼ inches. The boiler then leaked at the rivets. At 725 lbs. pressure, the vertical seam between rings A and B, and the butt-joint in ring B showed cracks. F. J. R.

559. *Tests of Machinery on Board Ship.* (Mech. Eng. 4. pp. 626–629, Oct. 28, 1899. From **B. C. Bryan** and **W. W. White,** of U.S. Navy, in Jour. American Soc. of Naval Architects.)—These tests give economic results obtained from the water-tube boilers and the main and auxiliary engines of the American lake steamer *Pennsylvania,* the boilers having been fired by a mechanical underfed stoker, using an inferior quality of slack coal, with forced draught from a Sturtevant blowing-fan which delivered the air through tuyere blocks—no air entering the fire from the ashpit. A test sample of the coal yielded calorific power equal to 11,790 British thermal units per pound when dry. The quantity of steam used by each of the auxiliary engines, and also the amount required to work the stokers, were, in addition, separately ascertained.

The boilers were of the Babcock and Wilcox marine type, with generating tubes 2 inches in diameter, No. 10 B.W.G. in thickness; each boiler occupying a space of 9 ft. 3 in. long, 12 ft. 6 in. wide, and 16 ft. 8 in. high, and having 3,000 square feet of heating surface. They weighed, without water, 145,860 lbs. (about 65 tons), and with water, 179,352 lbs. The working steam pressure was 250 lbs. per square inch. The weight of each stoker complete was about 3,500 lbs. The coal was fed continuously from a hopper by a screw conveyer into the central magazine of the stoker, in which it was gradually pushed upwards until it covered the tuyeres or air-blocks through which the fan blast was directed, both towards the central magazine and towards the outside of the fire. Each stoker had a side door through which the fuel on the dead grate was sliced at about twenty-minute intervals, and thoroughly clinkered and cleaned every six hours. These doors also permitted stoking by hand when desired, or in case of any break-down of the mechanical-feeding arrangement, but their opening afforded the only occasions on which smoke was produced. The following is a summary of the tests made—those marked *No. 6 (a, b, and c)* having been of short duration, to show the effect of reduced boiler pressure:—

SUMMARY OF TESTS OF MACHINERY ON STEAMER "PENNSYLVANIA."

Number of test / Date (1899)	1 May 28[1]	2 May 30	3 May 30–31[2]	4 May 31[3]	5 June 1[4]	6a June 1	6b June 1	6c June 1
Duration of test, hours	6	6	6	6	6	3	2	1
Average boiler pressure, gauge	242·0	244·2	240·8	245·3	245·0	197·4	129·8	108·3
Main engines : Steam pressure at engines	239·4	238·1	237·2	241·8	241·8	193·4	125·8	104·3
Vacuum, inches	24·35	23·56	22·73	22·71	23·67	23·40	21·60	21·16
Cut-off in high-pressure cylinder	·644	·658	·798	·542	·656	·656	·656	·656
M.E.P. reduced to low-pressure cylinder	31·48	31·70	36·93	26·24	32·01	25·71	15·59	11·87
Revolutions	77·33	74·45	79·44	66·31	73·74	67·10	51·02	44·93
Indicated H.P.	1,206·71	1,169·77	1,455·04	862·78	1,168·88	855·87	394·94	264·89
Feed water : Average temp. leaving heater	222	213·2	219	226·5	181·5	200·1	217	218
Total lbs. : Fed to boilers	122,439	116,136	146,089	89,566	98,026	45,937	18,390	7,615
Used by main engines	103,509	100,167	125,711	76,351	...	38,818	13,630	5,303
Used by auxiliaries and stokers	18,930	15,969	20,378	13,215	...	7,119	4,760	2,312
Lbs. per hour—main engines—total	17,252	16,694	20,952	12,725	...	12,939	6,815	5,303
Main engines—per I.H.P.	14·30	14·27	14·40	14·75	...	15·12	17·26	20·02
Auxiliaries—total	3,155·0	2,661·5	3,396·3	2,202·5	...	2,373·0	2,380·0	2,312·0
Per I.H.P. developed by main engines	2·61	2·28	2·33	2·55	...	2·77	6·02	8·73
Total per I.H.P. developed by main engines	16·91	16·55	16·73	17·30	16·77	17·89	23·28	28·75
Exhaust steam actually sent to feed heater[5]	14·78	13·02	13·08	13·83	...	10·59	17·41	18·79
Total steam used by auxiliaries, per cent.	15·46	13·75	13·95	14·75	...	15·50	25·88	30·36
Coal : Total, lbs.	14·400	14,200	18,000	11,800	14,750	...	...	...
Per cent. of moisture	3·3	3·3	3·3	3·3	3·3	...	...	...
Total, dry, lbs.	13,925	13,731	17,406	11,411	14,263	...	...	...
Total, dry, per hour, lbs.	2,321	2,289	2,901	1,902	2,377	...	...	...
Total dry, per I.H.P. hour for main engines	1·63	1·69	1·72	1·88	...	...	...	...
Total, dry, per hour for all machinery in use	1·92	1·96	1·99	2·20	2·03	...	...	...
Refuse : Total	2,183	2,575	3,800	2,463	...	...	...	...
Per cent. in dry coal	15 68	18 75	21·83	21·58	...	...	...	...
Water evaporated, per lb. : Dry coal—Actual conditions	8·79	8·46	8·39	7·85	8·25	...	...	...
Water evaporated, per lb. : Dry coal—From and at 212°	9·24	8·97	8·85	8·21	9·02	...	...	...
Water evaporated, per lb. : Combustible—Actual conditions	10·43	10·41	10·74	10·01	...	...	...	...
Water evaporated, per lb. : Combustible—From and at 212°	10·96	11·03	11·32	10·74	...	...	...	...

[1] Preliminary tests ; weight of coal used unreliable. [2] Auxiliary water exhausted to atmosphere by blower equal 432·8 lbs. [3] Leak around gland of feed pump during test equal 396 lbs. [4] Total feed water weighed only during five hours of test. [5] Given in per cent. of total steam used for all purposes.

The main engines were of the usual vertical, inverted, direct-acting type, arranged for quadruple expansion, with a jet condenser—the maximum H.P. being 1,600. The original paper gives details of sizes and make of the various parts of the machinery.

The average quantity of steam consumed per hour by the various auxiliary engines, which were mostly compound engines (excluding the stoker motors), is shown by the following table of results of tests made on May 28 :—

Auxiliary.	Steam Consumption per Hour.			
	Table I.	Table II.	Table III.	Table IV.
	Lbs.	Lbs.	Lbs.	Lbs.
Air pump	721	715	828	613
Feed pump	487	468	595	350
Bilge pump	275	275	320	240
Water-service pump	146	154	156	150
Auxiliary pump	330	...	...	...
Starboard dynamo	...	480	480	...
Port dynamo	671	...	...	...
Steering engine	125	125	125	125
Fire-room blower	622	692	725	550
Total	3,377	2,909	3,229	2,028

In addition to these, the stoker motors showed an average consumption of 23·1 lbs. of steam per hr. per motor, the total quantity for all the stokers amounting to 138·6 lbs. per hr. The cost of operating all stokers and blower, based on these results, was 4·29 per cent. of the total steam generated. Allowing for the blower exhaust steam having been passed through the feed heater, the net cost of the stoker installation is taken as equivalent only to 1·68 per cent. of the total steam.

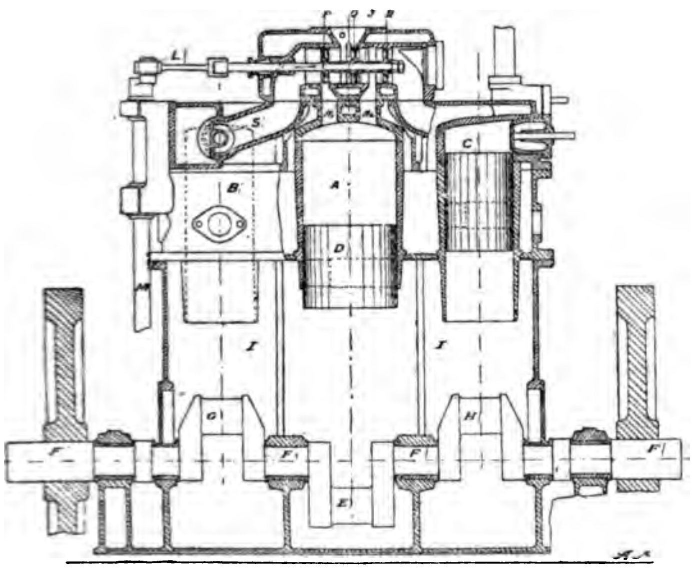
The exhaust steam from the auxiliaries was employed in a feed heater, but when the temperature of the feed water was increased to about 225° F., or higher, the back pressure from the heater shell caused irregular working of the pumps. The upper limit of feed heating appeared to be about 200° F., or an average of approximately 95° F. increase in temperature of the water taken from the hot well, the auxiliaries then consuming about 10·5 per cent. of the total steam generated. F. J. R.

560. *Flow of Water through a Surface Condenser.* **M. Longridge.** (Mech. Eng. 4. pp. 602–603, Oct. 21, 1899. From the Annual Report of the chief engineer of the Engine, Boiler, and Employers' Liability Insurance Company.) —Little is known about the pressure required to force the circulating water through a condenser. The author made an experiment on a condenser containing 679 tubes, ¾-inch external diameter, and 6 ft. 2 in. long. The circulating water was supplied by a centrifugal pump through a 6-inch pipe connected to the bottom branch of the waterhead of the condenser; traversed the length of the condenser twice, and flowed away from the upper part of the condenser through a 6-inch pipe.

In one experiment the quantity of circulating water was 1·72 cubic feet per second, and the difference of pressures in the inlet and discharge pipe allowing for the difference in level, was 3·05 feet head of water. The discharge pipe was not full of water, and therefore the figure given does

represent the head lost in the condenser. Assuming the discharge pipe to have been half full, the author calculates that the resistance of the condenser was equivalent to a head of 4·25 feet. In another experiment, in which the quantity of circulating water was 1·21 cubic feet per second, the resistance of the condenser was 2·45 feet. The resistance therefore varied approximately as the square of the velocity. The greater part of the loss probably occurred at the entrance and exit from the tubes, and in passing through the narrow opening in the distance piece of the waterhead. If the length of the tubes had been doubled, the total resistance of the condenser would not have been materially increased. A. S.

561. *Improvements in Gas Engines.* (Automotor Journal, 4. pp. 160–161, Jan., 1900.)—Messrs. Crossley and Atkinson, of Manchester, have adopted the "compound" or two-stage expansion principle in internal combustion motors. The vertical engine (see fig. of sectional elevation) has two high-pressure cylinders, B and C, into which the charges of gas and air are drawn, compressed,



ignited, and expanded, and exhausted on the ordinary Otto cycle. The explosion or working strokes are made alternately, giving an impulse every revolution. After the working stroke in either high-pressure cylinder the exhaust takes place into the low-pressure cylinder A through the exhaust valve passages and the ports in the piston valve J, and N_1 or N_2, whilst the port, O, leads to the atmosphere. The pistons of the H.P. cylinders are connected to crank-pins, G and H, and make their inward and outward strokes together, but 180° from the crank-pin E of the low-pressure piston D. In the Fig., the left-hand high-pressure piston has completed its upward exhaust stroke, the exhaust valve, S, being open, and the gases passing through N_1 have already done their work on B during its down stroke, whilst the compression stroke in C is completed. Next we have the upward exhaust stroke in A, and the downward suction in B, and explosion in C. Then follows the exhaust from C, doing work in A, during compression of charge in B, and so on.

In this way power is given out by the low-pressure piston once every revolution, and between the working strokes in the high-pressure cylinders.

The low-pressure cylinder is twice the area of the high-pressure cylinders and their ends are open to an enclosed crank-chamber I, the L.P. piston and rod are about the weight of the two H.P. pistons and their connecting-rods, so that by balancing the rotating parts, the engine is suitable for running at a high speed without causing serious vibration. The cycle of operations is completed during one to-and-fro movement of the piston-valve whilst the crank-shaft makes two complete revolutions, with an impulse from each of the H.P. cylinders, and two working strokes of the low-pressure cylinder.

W. R.

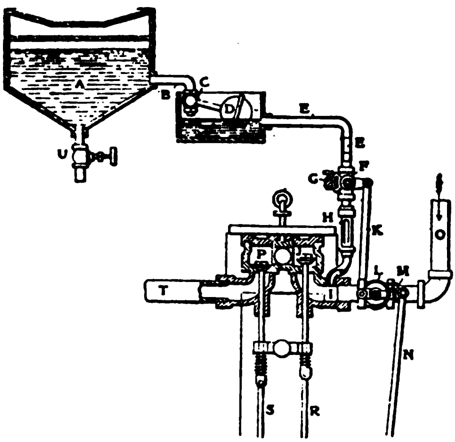
562. *Griffin's Oil Launch-Engine.* (Engineering, 68. pp. 670–671, Nov. 24, 1899.)—The novel feature of Griffin's oil engine, like his gas engine, is the vertical marine form, and the use of two cylinders with a single cross-head and connecting-rod, giving an impulse every revolution. The engine is non-reversible; hence to go ahead or astern two independent propeller screws are provided, one right-handed and the other left, one being mounted on a hollow shaft of Delta metal outside the solid steel shaft carrying the other screw, and both controlled by a lever. To start the engine the fly-wheel, which is connected to its shaft by a clutch, is released and the wheel put in rapid rotation by a hand wheel and chain, storing energy sufficient to carry the engine through two or three revolutions when the clutch is thrown into gear. The vaporiser is heated by the exhaust gases passing around it. To vaporise the oil it is first sprayed or atomised by an air blast at a constant pressure of 10 lbs. per square inch, and then heated in the vaporiser by hot air and radiation to avoid distillation of the oil. The combustible charge is diluted with the products of combustion until the best rate of combustion is obtained so that the engine runs smoothly, without the shock or knock produced by sudden explosion. The governor controls a small air valve. When the air is cut off no spray is formed, and there is no explosion in the cylinders. The illustrations show views of the engine and two propellers, with sections of these and the cylinders and vaporiser. The indicator diagram gives the mean pressure as 70 lbs. per square inch. The engine is fitted in a launch, which attained a speed of seven miles an hour on the Thames at Kingston. W. R.

563. *Stanley Steam-Car.* (Indus. and Iron, 27. pp. 397–398, Dec. 15, 1899.)—This describes a two-seated steam-car, the main features of which are the small vertical cylindrical steam boiler, placed under the seat, provided with 300 small vertical fire-tubes, 0·44 inch diameter, opposite to the bottom ends of which are 114 Bunsen burners, burning carburetted air produced by the evaporation of gasolene. Between the bottom tube-plate and the bottom of the boiler is a pair of plates into which are fitted a large number of short air-tubes, around the upper ends of which are drilled in the plate a number of small holes—through these holes issues the warm carburetted air inducing a current of air through the short tubes constituting a Bunsen burner. The gasolene or petroleum spirit is evaporated under slight pressure by being passed through a tube above the top tube-plate, and escapes through a small jet in a bell-mouthed opening into the space between the two plates at the bottom of the fire-box. The quantity of the vapour escaping at the jet is automatically regulated by a diaphragm which is controlled by steam pressure. The boiler is strengthened by a double winding of steel piano wire, 0·9 mm. diameter.

Motion is given to the car by a pair of vertical cylinders, 2¼-inch bore and 3¼-inch stroke, fitted with link reversing motion, and driving the rear axle by a chain : this runs on a sprocket wheel on the crank shaft and on the exterior of the differential gear on the axle. Fifteen gallons of water are carried, nominally sufficient for a 25-mile run. W. W. B.

564. *Secor's Kerosene Motor.* (Mech. Eng. 4. pp. 596–597, Oct. 21, 1899. From "American Machinist.")—The fuel used in this internal combustion engine is kerosene oil, having a heating value of 20,700 British thermal units per pound, costing about one cent. The charge contains a certain proportion of oil and air for perfect combustion. The speed is regulated by the governor, which controls the admission of both fuel and air, and thereby increases or decreases the volume of this perfectly combustible mixture.

The Secor motor is of the high-speed vertical marine form. The oil feed is by gravity, without any "carburetor" or pump. The oil falls from the supply tank A (in the fig.), into the constant-level tank V to obtain constant



head for the flow through the bent pipe E to the fuel admission valve F. The air admission is by O and the butterfly valve at L. The governor-rod N actuates both the valves L and F by the rod K. By an independent micrometer adjustment at G and M, the oil and air can be delivered to form a perfectly combustible mixture, whilst the regulation of the speed is effected by throttling the volume of the charge and so reducing the compression. The admission valve J is operated by the rod R, and the exhaust valve P by rod S, from cams of the usual type, timed on the Otto cycle. Ignition is by electric spark from a Rhumkorff coil, excited by current from six cells. It is stated that small sizes of this motor give power at a fuel cost of ½ cent per H.P. hour. W. R.

565. *Gobron and Brillié Autocar.* (Indus. and Iron, 27. pp. 429–430, Dec. 29, 1899.)—This describes the motor and gear employed by the Société Gobron and Brillié for their petrol motor vehicles. The motor has four pistons working in opposite directions in two vertical cylinders, the pistons being coupled to a three-crank shaft, the two lower pistons acting on one crank while the two upper pistons act on a crank fixed at 180° to that for the lower pistons. The explosions take place between the pistons in each

cylinder so that the motor is balanced both for impulse and weight of moving parts. The petrol is vaporised in the supply pipe leading to the admission valves, the quantity of petrol required per double stroke being fed by means of a rotating toothed cone disc, which is operated from the crank shaft of the motor in such a manner that one toothful of petrol is delivered per revolution to the vaporising chamber, except in the case of the speed of the motor exceeding the normal when the governor comes into action and cuts off the supply. The air admission to the vaporiser is arranged so that part of the air is sucked through a passage opening into the tooth which is full of petrol, and thus the petrol is swept with the air into the vaporiser. The motor drives by means of a spur gear through a friction clutch on to a countershaft; this in turn drives the countershaft, carrying the sprocket pinions of the chain drive by means of one of three sets of spur wheels and pinions, which give three speeds to the vehicle. This countershaft carries the differential gear, and, at its ends, the sprocket pinions which drive through pitch chains on to sprocket-wheel rings carried from the spokes of the rear road wheels. The steering of the vehicle is on the Ackerman system, and is controlled by a hand wheel which operates the pivots of the steering wheels through a form of epicycloidal gear; this gives a "variable multiplication of the ratio of movement between the hand wheel and the front road wheels." Three band brakes are fitted, one on the chain pinion countershaft and one on each of the driving road wheels. W. W. B.

566. *Darracq Autocar.* (Automotor Journal, 4. pp. 106–108, Dec., 1899. Adapted from an article by **L. Baudry de Saunier** in La Locomotion Automobile.)—This is a light four-wheel carriage, to seat two or four persons, driven by petrol motor, having a single horizontal air-cooled cylinder, designed by Bollée, and capable of giving 5 H.P. at 800 revolutions per minute. The motor is carried at the front end of the tubular under-frame, and is placed with the combustion chamber in front so as to get the full benefit of the cooling effect of the stream of air when the vehicle is in motion. On an extension of the crank shaft to one side of the crank case is mounted a four-speed belt cone from which the power is transmitted by a single belt to a corresponding four-speed cone on a countershaft carried at the back of the under-frame. This belt cone drives, through a friction clutch, a spur pinion gearing with a spur wheel on the exterior of the differential gear, which is mounted on the driving axle of the vehicle. Reverse motion is imparted to the carriage by means of internal spur gear, which, when brought into action, reverses the direction of rotation of the speed cone on the crank shaft of the motor. The carriage body is connected to the under-frame in such a manner as to be readily detachable. The body and frame are supported from the axles by leaf springs, and are further insulated from shocks due to rough road surfaces by means of pneumatic tyres on the wheels, which are of the cycle type. Steering is effected by the front wheels on the Ackerman system. Three band brakes are available for checking the motion of the vehicle in either direction. W. W. B.

567. *Bennett and Thomas Petrol Motor.* (Automotor Journal, 4. pp. 99-102 Dec., 1899.)—This is an engine worked with carburetted air, provided with two cylinders on opposite sides of a two-crank shaft, the centre lines of the cylinders being separated by a very short distance. The pistons and connecting-rods are similar to ordinary practice, but the pistons have very litt clearance, the necessary compression and combustion space consisting of o

long passage connecting the outer ends of the two cylinders. In branches from this passage are the seats of the two piston valves, one admission and one exhaust, worked by a simple arrangement of cam-actuated levers of the second order. Electric ignition is employed, and the governor acts on an ordinary butterfly valve. W. W. B.

568. *Ignition or Sparking Tube.* (Automotor Journal, 4. p. 99, Dec., 1899. **L. Baudry de Saunier,** in La France Automobile.)—The main point in this ignition or sparking plug is the form of housing given to the porcelain plug and insulation which permits the use of a two-part porcelain, through which one conducting wire passes. Object, to keep down temperature of outer projecting porcelain and reduce breakage. W. W. B.

569. *Buchet Variable Speed-Gear.* (Indus. and Iron, 27. p. 418, Dec. 22, 1899.)—The pulleys of this belt speed-gear are, as in well-known devices, made in segments fitted upon pairs of radiating guide-pieces, one of which is normal to the axis, and the other set at about 45°, the whole of these latter guides forming an interrupted cone. When this cone of guides is moved to or from the normal radiating guides, the pulley segments slide radially in or out respectively, just as a door-latch slides in its guide when pushed against the hasp. The pulley segments, when close together, form a pulley about one-half the diameter of the corresponding pulley when all its segments are separated with the maximum space between each. W. W. B.

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570. *Modern Steam Engine Tests,* 1888–1899. (Engineer, 88. p. 377, Oct. 13, 1899.) Three tables of twenty-nine tests.

571. *Heat Engines and Steam Turbines.* **C. A. Parsons.** (Electrician, 44. pp. 83–84, Nov. 10, 1899.)—Presidential address to the Institution of Junior Engineers.

572. *Evolution of the Stationary Steam Engine.* **A. R. Robertson.** (Instit. Civ. Engin., Proc. 138. pp. 353–363, Oct., 1899.)—Historical.

573. *Shaft Governor.* (Engineering, 68. p. 707, Dec. 1, 1899.)

574. *Steam Engine Governors.* **R. H. Smith.** (Feilden, 1. pp. 287–306, Oct., 1899.)

575. *Recent Practice in Steam Boilers in Great Britain.* **W. D. Wansbrough.** (Cassier, 17. pp. 33–47, Nov., 1899.)—A description of various types of boilers and their respective advantages and disadvantages. J. T. R.

576. *Compound Direct-Acting Boiler Feed Pump.* (Engineering, 68. p. 690, Dec. 1, 1899.)

577. *Steering-Gears with Two Pivots.* (Automotor Journal, 4. pp. 58–61, Nov., 1899; also Le Génie Civil and Engineering.)—A theoretical study.

578. *Utilisation of Blast Furnace Gases in the Generation of Electricity.* (Elect. Rev. 45. pp. 985–987, Dec. 15, and 991–992, Dec. 22, 1899.) See also Abstracts Nos. 991, 992, 993 (1898), No. 1258 (1899), and No. 297 (1900).

GENERAL ELECTRICAL ENGINEERING.

579. *Vulcain Prepayment Energy Meter.* (Ind. Élect. 8. pp. 487–490, Nov. 10, 1899.)—After describing the ordinary Vulcain meter (see 1899, Abstract No. 1419), an illustrated description is given of the supplementary prepayment attachment. This mechanism makes use of differential gear, and is so arranged that upon introducing a suitable coin and turning a key a switch is closed and a spring is wound up. The spring tends to restore the mechanism to its original position, but is controlled by an anchor escapement gearing with the meter proper. When a given quantity of energy has been used by the consumer, the switch is released, opening the circuit. The details cannot be explained without figures. Means are provided for changing the price of energy, and for checking the number of coins introduced.

A. H. A.

580. *O'Keenan Electricity Meter.* **E. O'Keenan.** (Ind. Élect. 8. pp. 505–510, Nov. 25, 1899.)—The aim of the inventor was to construct a motor which should have as nearly as possible an electrical efficiency of unity, when the counter and applied electromotive forces would be equal, and the speed of rotation proportional to the potential difference between the terminals. To this end a strong permanent magnet is used, with an iron cylinder fixed between the poles as in a d'Arsonval galvanometer ; in the narrow air-gap rotates an armature consisting solely of a shell of flat coils, cemented together, and connected with a small commutator. The iron core is supported by a bracket entering the open end of the armature ; the latter is carried by a spindle resting on a jewelled centre and guided at the upper end, and drives the recording train by means of a fine worm. No retarding device is employed, and friction is reduced to a minimum.

The instrument has various applications : (1) Connected with a battery of constant E.M.F., the dials record *time*, and may be graduated in hours, minutes, &c., thus constituting a clock, which, as the current is excessively small, may theoretically run for years without attention ; or it may be used for telephonic service, to record the time the telephone is in use. (2) For distribution at constant current, the instrument is connected through a high resistance with the consumer's terminals, and records volt-hours, and indirectly watt-hours. (3) For distribution at constant pressure, the instrument is joined in shunt to a very low resistance in series with the consumer's circuit, recording ampere-hours, and indirectly watt-hours. If it is necessary to compensate for friction, small though it be, an independent source of E.M.F. may be utilised to supply the friction torque. (4) By joining the middle wire to the middle of the low resistance mentioned in the preceding case, the instrument is adapted for recording the ampere-hours supplied to a three-wire circuit. (5) An analogous arrangement for a special case of five-wire supply is described. (6) For charging and discharging accumulators, a arrangement similar to that of (4) is explained, the instrument acting as reversible ampere-hour meter, and making allowance for the inefficiency the battery.

The instrument is independent of variations of temperature and of t resistance in circuit with it except at extremely low speeds, and cannot ted by external vibration, nor do external magnetic fields affect its indi

tions, all of which faults are commonly present in other meters. The practical form of the instrument is illustrated, and it is stated that for a meter of 5 amperes capacity the shunt resistance is 0·1 ohm, the armature 12 ohms, and the meter starts with from 0·5 to 1 per cent. of the maximum load, or about 0·03 ampere in the main circuit; the armature current is then 0·0002 ampere, the potential difference 0·003 volt, and the power $0·6 \times 10^{-6}$ watts. The armature current is almost constant at all loads. The economy of this type of meter is urged in favour of its use on constant-pressure circuits, instead of watt-hour meters with shunt coils, which are constantly absorbing energy. A. H. A.

581. *Insulation of Air Space Cables and Temperature.* **Deflacellière.** (Écl. Électr. 20. pp. 267–272, 1899, and Annales Télégraphiques, 25. pp. 95–117, 1899.)—A two-wire cable having 1 mm. coppers insulated with two 0·09 mm. papers, and covered over all with two more paper strips, was covered by a lead tube 5 mm. internal diameter without previous drying. At 16°, 24°, 40°, 60°, and 80°, the insulation was 80, 40, 17, and 2 megohms respectively.
M. O'G.

582. *Speeds and Standard Periodicities.* **E. K. Scott.** (Elect. Rev. 45. pp. 996–997, Dec. 22, 1899.)—In March last the Uniformity Committee of the Institution of Electrical Engineers published its report on the adoption of a standard of periodicity in alternating current working. The Committee recommended 50 periods per second for all ordinary work, 25 periods for power transmission on a large scale, and 100 periods per second for exceptional cases of house-to-house transformer supply.

The author points out that the speeds of steam or gas engines as constructed at present are for the most part not adapted to these frequencies.
W. G. R.

583. *Effect of Governors on Parallel Running of Alternators.* **L. Wilson.** (Instit. Elect. Engin., Journ. 28. pp. 389–398, 1899. Paper read before the Students' Section.)—The author explains the interactions occurring between the armatures of two alternators, which are coupled together in parallel, when not in phase. The "swinging" action which takes place between the two is studied theoretically, and also its effect on the governors of the engines; the conclusion being arrived at that quick-acting, sensitive governors are to be avoided. E. D. P.

REFERENCES.

584. *The Suppression of Arcs in Switches, Fuses, &c.* **E. K. Scott.** (Electrician, 44. pp. 218–221, Dec. 8; pp. 256–257, Dec. 15; and pp. 290–292, Dec. 22, 1899. Paper read before the Northern Society of Electrical Engineers.)—A fully illustrated paper describing in detail the most well-known switches and fuses, high and low tension, and the principles employed in their design. E. D. P.

585. *Chapman Voltage Regulator.* (Amer. Electn. 11. pp. 488–489, Oct., 1899.)—Illustrated description of an apparatus for automatically regulating the supply pressure of main generators. (See 1898, Abstract No. 987.) E. D. P.

586. *Street Box for Electric Supply.* (Ind. Élect. 8 pp. 388–392, Sept. 10, 1899.)—Descriptions of various street boxes for the ready supply of electricity to automobiles.

GENERATORS, MOTORS, AND TRANSFORMERS.

587. *Involutes for Armature Connections.* **P. Girault.** (Ind. Élect. 8. pp. 510–512, Nov. 25, 1899.)—The author points out that the normal distance between successive involutes of a circle is always constant, and if the end connections of an armature are given this shape, the space for insulation between them will be of constant thickness. Treating the matter analytically, the author deduces formulæ and draws up a table and curves to facilitate calculations for different radii and angles spanned, but notes that as the data are generally fixed by other considerations, the involutes obtained can be used only as guides to the tracing of a suitable curve. A. H. A.

588. *Hysteresis in Armature Cores.* **E. K. Scott.** (Electrician, 44. pp. 214–215, Dec. 8, 1899.)—The author points out that the formula of C. P. Steinmetz for the hysteresis loss in the cores of alternate-current transformers cannot be applied to armature cores, and gives a numerical example showing that there is no relation between the values calculated from this formula and those ascertained by experiment.

Referring to the experiments of F. G. Baily and J. A. Ewing on the subject of rotating fields, the author discusses their bearing on the design of armature cores, and considers that in direct-current armatures working at a high induction density the hysteresis loss may have a low value, but in alternators the Steinmetz formula may be approximately correct.

The possible effects of vibration are also briefly dealt with. A. H. A.

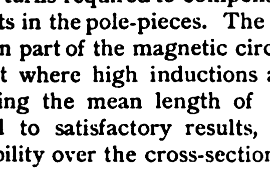
589. *Magnetic Flux in Armature Cores.* **W. E. Goldsborough.** (Amer. Instit. Elect. Engin., Trans. 16. pp. 481-500. Discussion, pp. 501–508, Oct., 1899.)—The author determines the flux density at different points in the core by dividing that portion of a lamina that lies between the centre lines of two adjacent poles into paths of equal magnetic reluctance connecting equipotential surfaces. These paths are determined by first equalising their reluctance on the basis of a permeability of the iron of unity, and then correcting for the variations in the permeability with the varying densities by successive trial. He takes a six-pole 110 kw. railway generator and shows that the density near the inner surface of the core at no load is a little less than 3,000 gausses, while just below the teeth it is a little over 21,000 gausses. Assuming uniform distribution, the density would be 7,220 gausses, and the core loss from hysteresis 492 watts, but with the uneven distribution shown it is 668 watts, or 35 per cent. greater. At full load the distribution is still more uneven, and the core loss 830 watts. These figures refer to the solid part of the core below the teeth only. The loss in the teeth is 182 watts at no load, and 246 at full load and 27 per cent. must be added for eddy-current losses. The total loss is 1,000 watts at no load, and 1,370 at full load. A special apparatus was made for testing the flux distributions. It consisted of an electromagnet resembli[ng] one pair of poles of a multipolar dynamo, and a section of the armature. [A] number of holes were bored in the armature, perpendicular to the side fa[ces,] and exploring coils wound in each pair of holes. Curves are given show[ing] the flux distribution found by the exploring coils.

Discussion.—**Steinmetz** remarked that machines with armature iron [ex]tending down to the shaft and poles covering 80 per cent. of the pole arc

show unequal distribution more than shallow armature cores with long distance between the poles. Experience has shown, however, that no effect of this kind appears of a magnitude to make itself felt without special investigation, so that it appears that with the relative dimensions used in most machines the effect is small, though undoubtedly existing. Where the flux is uniform at no load, change of load will not alter the distribution noticeably; it depends, however, on the relative proportion of armature reaction to field excitation.

R. B. R.

590. *Calculations Regarding Toothed-Core Armatures.* **F. Niethammer.** (Elektrotechn. Ztschr. 20. pp. 766–771, Nov. 2, 1899.)—In calculating the ampere-turns required for the air-gap the author assumes that the distribution of the magnetic lines is as shown in the accompanying sketch, the tufts of lines which proceed from the teeth spreading out fan-like until they reach the polar surface. If K stand for the number of lines proceeding from each tooth, the ampere-turns required for the air-gap are given by $K \Big/ \Big\{ 1{\cdot}257 l (n+1) \tan^{-1}\Big(\frac{(n-1)a}{b}\Big) \Big\}$, where l is the length of the pole piece measured parallel to the spindle, and the meanings of a, b and n are given by the sketch. The lines as they enter the pole-piece are not uniformly distributed, being more crowded over the areas which are immediately opposite the teeth. At a certain distance from the polar surface the distribution of the lines in the pole-piece becomes practically uniform. As the armature rotates, the local pulsations in the magnetic induction in the region of the pole-piece just considered give rise to hysteresis and eddy-current losses. The author deduces elaborate formulæ for these losses, as well as



a formula for the ampere-turns required to compensate for the demagnetising effect of the eddy-currents in the pole-pieces. The calculation of the ampere-turns required for the iron part of the magnetic circuit is next considered, and the author points out that where high inductions are used, the method commonly employed of taking the mean length of path and mean value of induction does not lead to satisfactory results, on account of the great variations in the permeability over the cross-section of the iron. He develops a method which is free from this objection, the varying length of path and varying permeability being taken into account. Considering next the case of alternate-current motors, the author emphasises the advantage of partially closing the slots, the induction being thereby rendered more uniform, with consequent reduction of hysteresis and eddy-currents; closing the slots entirely would greatly increase magnetic leakage. Formulæ are next developed for the leakage coefficients of stator and rotor, on the assumption of a standard form of half-closed slot; these formulæ, however, are much too complicated to be reproduced here.

A. H.

591. *Short-Circuit Current of Alternators.* **A. Rothert.** (Elektrotechn. Ztschr. 20. pp. 619–622, Aug. 31, 637–638, Sept. 7, and pp. 657–659, Sept. 14,

1899.)—The author shows how, from the curve connecting the E.M.F. on open circuit with the exciting current (curve a) and that connecting the short-circuit current of the alternator with the exciting current (curve β), it becomes possible to predetermine graphically the exciting current corresponding to any load of known power-factor. Let this load take a current I at a terminal P.D. of V volts, and let the current lag behind P.D. by an angle ϕ. The first step consists in finding the E.M.F. E_1 which is required (a) to provide the terminal P.D. and (b) to maintain the current I against the resistance of the armature (these two components being added vectorially). Using curve (a), we find the exciting current I_a which is required to produce E_1 volts on open circuit. Next, from curve (β) we find the exciting current I_β required to maintain a current I through the short-circuited armature. From I_a and I_β the required total exciting current is obtained by the following construction : Let I_a and I_β be taken to represent two sides of a triangle, and let the angle between them be made equal to $90° + \phi$. Then the closing side of the triangle gives the exciting current corresponding to the given load. If the curve (β) is not available, I_β may be roughly estimated, for a three-phase machine, by making use of the formula—

$$I_\beta = \frac{C}{2S} I \sqrt{2} . 1{\cdot}5 = 2{\cdot}12 \frac{C}{2S} I,$$

where C is the number of conductors per phase, I the current per phase, and S the number of turns in the field-winding. If we denote the value of I_β obtained by means of this formula by I'_β, and use I_β for the true value as furnished by the curve (β), then the ratio I'_β/I_β is, according to the author, found to vary between 0·65 and 1. The formula given above is based on the assumption that the field and armature ampere-turns are equal when the machine is run on short circuit, and that the currents follow the simple sine law. For a single-phase alternator,

$$I'_\beta = \frac{C}{2S} I \sqrt{2} . \frac{2}{\pi} = 0{\cdot}9 \frac{C}{2S} I,$$

the arithmetic mean of the armature current being used in this case instead of the maximum value. The author describes a number of interesting experiments on five machines of different types, and shows that the graphical construction described above gives results agreeing closely with experimental data. A. H.

REFERENCES.

592. *Double Voltage and Current Generators.* **A. D. Adams.** (Elect. World and Engineer, 34. pp. 742–743, Nov. 11, 1899.)—Article pointing out the advantages of combined systems, alternating and direct current.

593. *Bristol Electric Transformer Company's Factory.* (Lightning, 16. pp. 396–397 and p. 402, Nov. 2, 1899.)

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

594. *Drop in Alternating-Current Wires.* **C. P. Poole.** (Elect. World and Engineer, 34. pp. 780–781, Nov. 18, 1899.)—For the purpose of computing the difference between the bus bar E.M.F. and that at the load with any degree of convenience, the simplest method is to add together all the energy components of each element of the complete circuit; similarly add together all the inductive components, and then find the vector sum of these two arithmetical sums.

An example is given. W. G. R.

595. *Line Losses in Polyphase Transmission.* **G. T. Hanchett.** (Amer. Electn. 11. pp. 517-519, Nov. 1899.)—The author calculates the relative volumes of copper required in the various polyphase systems. It is assumed that a certain power has to be transmitted a given distance at a given voltage and with a given loss in a single line. The proportions of copper arrived at on these assumptions are:—

1.	Single phase	100
2.	Two-phase independent	100
3.	Two-phase Y balanced	100
4.	Two-phase mesh balanced	50
5.	Two-phase Y centre to earth	25
6.	Two-phase three-wire	72·6
7.	Monocyclic	100 + auxiliary
8.	Three-phase Y	75
9.	Three-phase Y common junction earthed	25
10.	Three-phase mesh	75

W. G. R.

596. *Electricity in Coal-Mining.* **J. P. Jackson** and **F. F. Thompson.** (Amer. Instit. Elect. Engin., Trans. 16. pp. 469–477. Discussion, pp. 477–479. Oct., 1899.)—The authors point out the drawbacks of power transmission by means of steam and compressed air, and favour the use of electrical transmission, using direct current for haulage, and polyphase currents for pumping and driving fans, in spite of the disadvantages of a mixed system. The plant of the Davis Coal and Coke Company at Thomas, West Virginia, is briefly described, and curves are given showing the nature of the haulage and coal-cutting loads. Bare wires are preferred for all purposes in mines, though the danger to life is pointed out.

In the Discussion, **E. A. Sperry** emphasised the danger, especially with alternating currents, and stated that motors were generally too small for their work. **W. S. Aldrich** stated that the use of electricity enabled abandoned mines to be profitably reopened and deeper veins to be reached. A. H. A.

597. *Test of Railway Generating Plant.* **E. J. Willis.** (Amer. Instit. Elect. Engin., Trans. 16. pp. 504–508, Oct., 1899.)—The plant tested consisted of a 800-H.P. Campbell-Tell water-tube boiler, a 800-kw., six-pole, G.E. railway generator, direct coupled to a Hoover, Owens and Rentschler

horizontal, tandem, compound, condensing engine running at 100 r.p.m. The feed pump and the condenser were operated by a separate boiler, so that all steam generated by the boiler passed through the engine. The water consumption was measured by a Worthington hot-water meter, which was accurately tested before and after the run. The draught at the grate was five-eighths of an inch. Readings were taken about every fifteen minutes. The load was as follows: One hour at 200 amperes, one hour at 300, one hour at 400, and one hour at 500 amperes. Some of the indicator diagrams are given, and the summary of the test, of which figures are given in full, is as follows :—

Load.	Power.			Evaporation.		Coal Consumed.			Steam.			Efficiencies.		
	Indicated H.P.	Electrical H.P.	Kilowatts.	Water per lb. of coal (actual).	Water per lb. of coal from and at 212° F.	Per indicated H.P. hour.	Per electric H.P. hour.	Per kw. hour.	Per indicated H.P. hour.	Per electric H.P. hour.	Per kw. hour.	Indicated H.P. per electric H.P.	Electric H.P. per indicated H.P.	Indicated H.P. per kw.
200 Amperes.	216	146	110	10·05	10·71	1·45	2·18	2·90	14·8	21·9	29·1	1·48	0·68	1·96
300 „	299	220	164	10·8	10·75	1·43	1·94	2·60	15·3	21·9	28·1	1·36	0·74	1·82
400 „	373	293	219	8·94	9·53	1·54	1·96	2·63	13·8	17·53	23·46	1·27	0·79	1·70
500 „	469	369	275	8·57	9·18	1·66	2·11	2·83	14·25	18·1	24.3	1·27	0·79	1·70

E. D. P.

598. *Electric Traction on the South London Railway.* **P. V. McMahon.** (Instit. Elect. Engin., Journ. 28 pp. 508–608. Discussion, pp. 609–632, Aug., 1899.)—This paper contains the results of tests and observations on electric locomotives on the underground City and South London Railway. The gauge of the line is 4 ft. 8½ in. The overall length of the electric locomotives, buffer to buffer, is 14 feet; their width is 6 ft. 10 in.; wheel base, 6 feet; and diameter of wheels, 2 ft. 3 in. Each locomotive has two motors, the armatures of which are fixed directly on the axles. The motors are arranged in series, and the regulating gear consists of a reversing switch, which changes the armature connections, a simple rheostat switch in series with the motors, and a main break switch. Particulars of the motors are given.

The author goes somewhat minutely into the difficulties he had in getting a suitable dynamometer to register the draw-bar pull, and also the various stages through which the experiments had to pass before a definite line of action was decided on. The readings were taken at 5-second intervals on ammeter, voltmeter, tachometer, and dynamometer, and although the needles vibrated considerably, the numerous curves and tabulated data show that the results agree with very fair accuracy.

The author fixes the maximum acceleration, either positive or negative, at 1·46 feet per second per second, corresponding to stopping in 20 seconds from a speed of 20 miles per hour. This does not cause discomfort to the passengers, and it is not too hard on the brakes and wheels. If for practic reasons it is not desirable to adopt a higher negative acceleration than 1·4 feet per second per second in bringing the train to rest, there is clearly a need to try and get a higher positive acceleration at starting.

Particulars are given of tests with motors of larger size than th originally used on the locomotives, which the experience detailed in earlier part of the paper showed were necessary. A series of observati

made on the effect of "varying the starting current" upon the acceleration of the train showed that with the ordinary series method of regulation the amount of current taken by the locomotive has not much effect (within fairly wide limits) on the time taken to run a particular section, or on the total energy drawn from the line.

Various experiments, which are detailed, point to the desirability of adopting series-parallel control in place of the ordinary rheostat switches first used. As the drivers were used to this class of switching-gear, a series-parallel controller, retaining the old form of rheostat switch, was developed. It consists of two switches operated by a single handle, that part of the controller which puts the motors into parallel being moved only at predetermined points. Magnetic blow-outs, or arc-suppressing devices, are not used, the motors not being put back into the series position until current is switched off.

In summarising, the author points out that :—

(*a*) The motor and locomotive tests show that, at starting, only about 78 per cent. of the total tractive effort at the tread of the wheel is given out at the draw-bar, and that the loss at starting is directly proportional to the tractive effort.

(*b*) After the locomotive commences to move, its losses decrease until a speed of about 9 miles per hour is reached, and then become fairly constant.

(*c*) The results of the draw-bar tests show that the tractive resistance per ton of train is 40 lbs. at the moment of starting, and that it drops quickly to 10 lbs. at 6 miles per hour ; between 6 and 13 miles per hour the resistance remains fairly constant, and then continues to rise almost proportionately to the speed, until a speed of 26 miles an hour is reached, when the resistance is about 21 lbs. per ton.

(*d*) Curves have a very important effect on the tractive resistance. Tests show that on a curve of 540 feet radius the tractive resistance is doubled. A comparison of the performances of several locomotives shows that the tractive force per ampere has an important bearing on the energy consumed for a given section. No. 12 locomotive, for example, with its low tractive force per ampere, takes 26 per cent. more energy than No. 15 for the shortest section, while on the longer section this is reduced to 6 per cent. For longer sections still, probably No. 12 locomotive would be more economical than No. 15.

(*e*) Although there is a great difference in the energy drawn from the line by the various locomotives, their efficiencies are not widely different.

(*f*) With plain series method of control the value of the starting current has not much effect on the total energy consumed for a given section. With the series-parallel method there is, however, a very great reduction in the energy consumed by adopting high starting-currents. The calculated performance diagrams show that, by altering the value of the starting-current when the motors are placed in parallel, there is a saving of 24 per cent. in time and 11·5 per cent. in watt-hours.

(*g*) Theoretically a higher rate of acceleration at starting is the more economical method of running a short section. The highest rate taken is 1·46 feet per second per second, the lowest that it was possible to adopt being 0·417 feet per second per second, the latter rate requiring 27·6 per cent. more energy than the former to run a 2,700-feet section.

(*h*) The acceleration at starting should be uniform, and to arrive at this the motor fields were successfully *shunted during* the starting period. Ex-

periments with No. 15 locomotive show that by shunting the field during the running period the energy consumed was increased about 50 per cent. without corresponding gain in speed.

(*i*) Calculations from tests show that a high rate of acceleration and a fair amount of coasting is a more economical method of running a short section than very rapid acceleration, necessitating the use of large currents for a few seconds and coasting for a large percentage of the time. The reduction in kilowatts per ton-mile, gained by very rapid acceleration, is deceptive, and must be considered in connection with increased cost of plant and the cost per kilowatt-hour.

Discussion.—**C. E. Grove** remarked that it did not seem to be sufficiently clearly recognised in the paper that the draw-bar pull is the total horizontal effort exerted by the locomotive minus that effort which is required to move the locomotive itself, and cannot, of course, be equal to the total effort of the locomotive. With regard to motor testing, he preferred the simple torque test to the Prony brake test. **A. M. Taylor** presented a curve connecting tractive resistance with speed, taken with one of the locomotives referred to in the paper. **R. P. Brousson** said that, according to his experience, the acceleration may be increased beyond 1·46 feet per second without discomfort to the passengers. What gives rise to discomfort is change in acceleration. Before changing from series to parallel the author allows the current, and therefore the rate of acceleration, to drop considerably. This would probably be felt by the passengers, especially when the trains are getting up speed. **R. H. Smith** advocated direct measurements of acceleration. **C. A. Carus-Wilson** said that in the first series of experiments made, the author had tried to increase the efficiency of the locomotive by simply increasing the number of turns on the armature. Under these circumstances, it is clear that in order to cover the given distance in the stipulated time it is necessary to shunt the fields. The effect of shunting the fields is to make the characteristic straighter than can be obtained from the simple magnetic curve of the motor; the efficiency at full load is slightly increased and that at light loads considerably diminished. Referring to the new locomotive which the author had designed, it is not surprising to find that he had not obtained a better ratio of kilowatt-hours to ton-miles. This is fully accounted for by the necessity for a larger driving wheel of 31 inches instead of 27 inches in diameter, to give clearance. **E. Wilson** gave a comparison between results obtained by Messrs. Siemens for locomotive No. 15 and those obtained by the author. **P. V. McMahon,** in replying, explained why no magnetic blow-out is necessary in the controller by stating that the paralleling contacts are not moved until the moment the motors are required to be put in parallel. Once the motors are in parallel they are left so until the current is entirely cut off. Referring to air resistance the author stated that measurements were taken, but there was great difficulty in getting accurate readings. He thought that the air resistance on the front of the locomotive in the tunnels was from 1 to 1½ lbs. per square foot at about 14 miles per hour. E. K. S.

599. *Buenos Ayres Electric Tramways.* **E. Manville.** (Street Rly. Journ. 15. pp. 698–700, Oct., 1899.)—Almost every street in the city has its tram line. The equipment is on American lines. Owing to high price of electrical energy, the feeder system is very complete: positive and negative boosters are used. A diagram of the distribution circuits is given, showing the calculations for drop of potential on trolley wires and rail return. To ensure good wear-

ing, the rails are made of best Bessemer steel containing not less than 0·45 per cent. of carbon, are cleanly rolled, each from a single ingot, are made to template throughout their entire length, and are carefully straightened by pressure and not by hammering. E. H. C.-H.

600. *Sheffield Corporation Tramways.* (Tram. Rly. World, 8. pp. 423–432, Nov. 2, 1899.)—About 24 miles of single line have been laid with 108-lb. rails and extra heavy 8-bolt fishplates, 3 feet long, weighing 80 lbs. per pair. The marine type boilers, 10 feet diameter by 10 feet long, have Ellis and Eaves' induced draught, "Purves" ribbed furnace and "Serve" tubes. Each evaporates 8,000 lbs. per hour at 160 lbs. per square inch. No tall chimney shaft is required, but each boiler has a short steel funnel just taken through the roof. There are three Allis-General-Electric 225 kw. sets, with 12 feet, 7 ton, flywheels. The guaranteed water consumption at three-quarter load is 18 lbs. per I.H.P. hour, condensing. The guarantees give an efficiency of 94 per cent. a full load, and 93 per cent. at half load.

Special braking arrangements include a trailing slipper brake, which removes the weight from the wheels and transfers it to wood blocks sliding along the rails: also electric brakes and trailing wedge blocks. E. H. C.-H.

601. *Haulage Systems Compared.* **T. Parker.** (Instit. Civ. Engin., Proc. 138. pp. 411–413, Oct., 1899; Engineer, 87. p. 565.)—Apart from other disadvantages, the cost per mile for horse trams with 26-passenger cars, weighing 2¾ tons empty, averages 7·78d. :—drivers' and conductors' wages, 2·50d.; horses, forage, harness, renewal, attendance, &c., 4·53d.; management and general expenses, 0·75d. For steam trams the average is 8·99d. per car-mile: drivers and conductors, 3·50d.; loco. and car repairs, 2·25d.; fuel, 1·65d.; lighting, 0·33d.; management and general expenses, 1·26d. Compressed air has better prospects of success than steam; the dead-load per passenger is less than with steam, and probably the efficiency greater. Endless-rope traction is obsolete. For gas engines on tram-cars there are no practical data. In electric traction the power per car-mile with accumulators is 4·6 E.H.P.-hours as against 2·15 E.H.P.-hours (and higher speed) with overhead wires. On the overhead system with a 30-passenger car weighing 4·3 tons empty, the costs per car-mile average 3·16d. :—drivers' and conductors', 2·49d.; generation, 0·46d.; car, 0·04d.; lighting, 0·02d.; management and general expenses, 0·15d. On the Liverpool Overhead Railway, electricity is under its worst conditions in comparison to steam, owing to the frequent stoppages; the average costs per mile there, with 140-passenger trains weighing 31 tons empty, are 4·32d., of which 0·42d. is for management and general expenses. For electric motor-cars the weight of accumulators has recently been reduced to ½ cwt. per H.P.-hour, or 5 cwt. of cells for a car which two years ago had required 16 cwt. The best example which the author has tested is: Weight of empty car, 9 cwt.; batteries, 5 cwt.; total, with 4 passengers, 20 cwt.; discharge, 12 amperes at 80 volts, giving 9 miles per hour on level with one motor making 1,200 revolutions per minute and double reduction gear: safe run, 40 miles. E. H. C.-H.

602. *Electric Railway Practice in America.* (Street Rly. Journ. 15. pp. 613–645, Oct., 1899.)—Compressed-air cars are now regularly operating the Twenty-eighth and Twenty-ninth Streets line in New York with great satisfaction; no data as to cost of operation are yet available. Over 90 per cent. of the entire street railway *mileage in* America is now operated

electrically, mostly by overhead trolley. In New York and Washington, with their efficient sewerage and favourable climate, the underground conduit system has worked well. In Chicago, twenty-five storage-battery cars have run over twenty-five miles of track for two years with fairly satisfactory results.

In roadbed construction the common practice is now to place creosoted ties, at about 30-inch centres, on a layer of broken stone, to spike 7-inch or 9-inch girder rails to the ties, and fill in between them with broken stone. Concrete substructure is costly and too rigid for passengers' comfort. Rails are almost universally ordered in 60-feet lengths, which nearly all mills can now supply. "Cast welding" has come largely into use; the verdict is that a smooth-riding track can be obtained and maintained by this means. The latest electric welding (see 1900, Abstract No. 605) is promising, though the cost is rather high.

In rolling stock the drift is towards long (30–35 feet overall) double-truck cars, even in some cities. Trail cars are abandoned as costing more for labour per passenger, largely increasing the accident account and involving switching difficulties at termini. On severe grades, or for rapid acceleration, the "maximum traction" type of truck is in general use. One of the most interesting experiments now being tried is the use of a "duplex" or "combination" summer and winter car, to overcome the difficulty of rainy summer days.

In motors the main qualities of the American type are: (i.) high efficiency through a wide range, (ii.) load and speed curves adapted to suit circumstances, (iii.) multipolar construction and separate coil armatures. Mechanical braking will shortly be adopted by many lines.

In power stations large size direct-coupled multipolar sets prevail, also water-tube boilers. In the best plants, economy in handling and storing coal has received special attention. Duplicate systems of piping are common, but many prefer "to place all their eggs in one basket and watch that basket." In the absence of condensing water, cooling towers have come into successful use. Nearly all the engines used in traction work employ modified Corliss valve gear. The largest steam set yet built is rated at 4,500 H.P. economical and 7,000 H.P. maximum load. In the best stations, power for railways has been produced at ¼d. per kw. hour, but in most it is still costing double this, these figures covering labour, fuel, water, material, and repairs, but excluding interest and depreciation.

In distribution, the latest practice is three-phase high-tension current distributed to substations containing stationary and rotary converters. Aluminium feeders are being tried.

Cable cars are now disappearing even from Chicago. In 1898 the Chicago City Railway Company operated its electric cars at 12·9 cents per car-mile, its cable cars (including trailers) at 10·8 cents, and its horse cars at 27·2 cents; while the earnings were respectively 22·7 cents per car-mile for the electric cars, 16·5 cents for the cable cars, and 16·6 cents for the horse cars.

The South Side Railway Company's generating station (one of the most economical in the world, its cost of operation being well below 0·75 cent per kw. hour) contains Allis-Westinghouse 4,000-H.P. sets, running at 80 r.p.m. under 160 lbs. steam pressure. It has Babcock boilers with automatic chain-grate stokers, fed by pendulum chutes communicating with steel storage bunkers over the boiler-room, into which coal is delivered by McCaslin conveyers. A water cooling-tower is used. Load fluctuations are lessened by two storage batteries, each about three miles from the central station, and each containing 263 cells of 750 kw. total capacity. They have given 4,300 amperes to the line. The batteries are in charge of the ticket-agent and

booking-clerk at one station and the train-despatcher at another, and the only duty of each is to throw in the circuit-breakers should they fly out. The average power output per car-mile ranges from 2 kw.-hours in summer to 3·52 kw.-hours in winter, the latter figure including electric heating of cars, and both including lighting, air compressors, station lighting, fans, and auxiliary motors. Coal screenings are chiefly used, costing 1·12 to 1·80 dollars per ton. The capacity of the fourteen chief power stations in Chicago totals 54,000 kw., the largest plant in one station being 9,600 kw. Photos of several stations are given.

The overhead construction is claimed to be durable and inconspicuous. One large company uses No. 0 copper trolley wire with No. 6 silicon bronze guard wire. Silicon bronze is also used for span wires in the city; $\frac{5}{16}$-inch stranded galvanised in the suburbs. The insulation is "Aetna" throughout. Another company has abandoned No. 0 trolley wire in favour of No. 00, because of the latter's greater strength and of its assistance to feeders. Stranded $\frac{3}{8}$-inch galvanised span wires are used with it: and guard wires, which are now deemed a menace to life and property, have been taken down and abandoned.

Two engravings show all the types of line material ever used on the Chicago City Company's system, one representing the present standard, in which malleable or other iron has been abandoned in favour of brass, because rust deteriorates it and also bridges the insulation. Discarded brass is melted down and is found cheaper in the long run than iron. Three insulations are invariably used between trolley wire and earth. Solder is no longer used for splicing trolley wire or attaching hangers, but only for feeder joints: soldering is found to anneal the trolley wire and cause crystallisation and breakage. At about 75° F. a sag of 8 to 10 inches is allowed in all spans of 115 to 120 feet. Clinch ears are used: they move slightly if trolley pole catches in the span wires. Lattice poles are discarded in favour of tubular iron poles in three sections, 7 inches, 6 inches, and 5 inches diameter, weighing 850 to 900 lbs. Corner poles have sections 8 inches, 7 inches, and 6 inches in diameter; strain poles weight up to 1,200 lbs. Poles are set in 6 feet of concrete and rest on hard wood boards. At the street surface an iron thimble 12 inches long encircles the pole; the thimble is 1 inch larger in diameter than the pole and when the latter is in position, concrete is run in up to a flange on the thimble. Poles are repainted every three or four years and depreciate $3\frac{1}{4}$ to 4 per cent. per annum, as against cedar poles, $6\frac{1}{4}$ to 7 per cent. Lead-covered rubber cables are the standard. All return circuit cables within two or three miles of the power house are made 30 per cent. greater in section than the corresponding out-going cables.

The North-Western Elevated Railway has erected 75,000 lbs. of bare aluminium feeder of 1,300,000 circular mils section, in which a secret weld is used. The motors now in use include 1,688 of the G.E.-800 (25 H.P.) type, 755 of the corresponding Westinghouse pattern besides larger motors, the total number being over 3,000. As the result of careful tests, of which a tabulation is given, the G.E.-55 (150 H.P.) motor with "L" controller has been selected as the best equipment for the Lake Street and North-Western Elevated Railways. Electric heating is general, the "Consolidated" heater being the type most used. "Falk" cast-welded joints are now the standard, 100,000 having been made. Copper bonds are then omitted, care being taken to clean the rail ends with sand-blast before welding. A brief account is given of the New North-Western Elevated Railway now in progress. It is the first elevated railway built originally for electric traction. E. H. C.-H

603. *Traction Data.* **W. B. Potter.** (Street Rly. Journ. 15. pp. 701-702, Oct., 1899.)—The General Electric Company's motors are rated at the H.P. which they will develop, with a temperature rise of 75° C. in one hour. The average H.P. required of a motor should not exceed 80 per cent. of its rating; its temperature rise under ordinary service conditions will then be about 60° C. If electric brakes are used the heating will be increased by 20 to 25 per cent. and a larger motor should therefore be used. The total H.P. (rated on the hour basis) for an ordinary city or interurban car may be taken as $\frac{1}{5}$(total weight in tons of 2,000 lbs. × maximum speed in m.p.h. on level). If electric brakes are used, $\frac{1}{4}$ should be written instead of $\frac{1}{5}$. The maximum speed is generally twice the schedule speed.

Excluding car friction, a tractive effort of 92$\frac{1}{3}$ lbs. per ton (2,000 lbs.) will produce an acceleration of one mile per hour per second on level track. On an ordinary street car the tractive effort during acceleration often rises to 200 or 300 lbs. per ton: on elevated or suburban lines 100 to 150 lbs. per ton is the usual maximum. From tests it has been found that the tractive efforts necessary to overcome rolling friction and air resistance are, for different weights and speeds of car, as follows:—

Weight of Car.	Speed, up to	Tractive Effort.
15 tons	25 m.p.h.	25 lbs. per ton.
15 „	50 „	50 „
25 „	25 „	20 „
25 „	50 „	25 „
100 „ (train)	25 „	15 „
Heavy freight train	25 „	6 to 10 „

The "tractive coefficient," or ratio of the total tractive effort to the weight on the driving wheels, should be at least 1 : 6. A series of tests gave the following results:—

	Tractive Coefficient.	
Dry rail	28 per cent.	Sanded, 28 per cent.
Thoroughly wet rail...	20 „	„ 25 „
Greasy moist rail......	15 „	„ 25 „

To approximate the capacity of power station required for a given service, the average energy required may be assumed to be 100 watt-hours per ton-mile of schedule speed for ordinary conditions of city or interurban service. If the stops are a mile or more apart this figure may fall to 60 or 70 watt-hours, while frequent stops and very high schedule speed will increase it to 120 watt-hours, or more. E. H. C.-H.

604. *Westinghouse Electro-pneumatic Car-control System.* (Street Rly. Journ. 15 pp. 703–708, Oct., 1899.)—G. Westinghouse has evolved a system for moving the controlling apparatus on any number of motor-cars by means of compressed air, whose admission to the several parts is effected by electrically operated valves, circuits to which are manipulated by one multiple-contact switch. On an extension of the ordinary controller spindle are fitted ratchet wheels into which pawls engage on the ends of the piston of the air cylinders. Applying the air-brake releases the controller. A new form of compound direct-connected rotary air compressor is used. *diagram* of the electric and pneumatic connections on two motor-cars *given. Also particulars* of a special truck. E. H. C.-H.

605. *Electric Welding of Rail Joints.* **R. F. Danforth.** (Street Rly. Rev. 9. pp. 575–577, Sept. 15, 1899. Paper read before the Street Railway Association at New York.)—Welding by bringing the abutting joints to a welding temperature has proved a failure because the homogeneity of the steel is destroyed. At Buffalo the Johnson Cômpany are now using a method by which the ball of the rail never reaches more than a dull-red heat, the weld being made between facing strips at the centre and ends of the splice bars. The surfaces to be welded are pressed together with a pressure of from 8 to 35 tons per square inch. After the weld is made, the head of the rail is ground to a true surface by an emery grinder. About 250 amperes at 500 volts are required, being transformed by a rotary converter to 300 volts alternating, and then by static transformer to 5 volts. The contacts are water-jacketed. A machine will weld four joints per hour. Expansion is provided for by special joints every 2,000 feet, and by leaving bolted joints at the special work.

Welded joints require no bonding and do not cost materially more than bolted joints plus bonding. Cast-welded joints give as good a result mechanically, but the electrical contact is not as good. Out of 8,100 welded joints, 17 had broken. E. H. C.-H.

606. *Methods of Picking up Current on Electric Railways.* **M. Schiemann.** (Deutsche Zeitschr. Elektrotechn. 6. pp. 166–168, Oct. 15, 1899.)—Sliding contacts are not quite satisfactory for high speed electric railways because of the wear; also the heat generated may make the metal seize. The author thinks it is better to use rolling wheels mounted on the carriage axles, the face of the wheel being sufficiently wide to keep contact with the middle rail on going round curves. Necessary elasticity can be given to the wheel to keep good contact, by having the spokes fitted with springs. E. K. S.

607. *Underground Conduit and Three-Wire Trolley System.* (Tram. Rly. World, 8. pp. 379–384, Oct. 5, 1899.)—A description of the conduit system to be used by the London United Tramways on two miles of track between Hammersmith Broadway and Young's Corner, Chiswick. The conduit and track construction are illustrated, and are similar to those used in New York. The slot will not exceed ¾ inch in width. One hundred cars, carrying 30 passengers inside and 38 outside, will be provided on Peckham maximum traction trucks. Each car will be 33 ft. 4 in. overall, and will have two trolley standards for use on the trolley sections beyond the London boundary. There will be two trolley wires over each track throughout, the two inner wires being connected to form the neutral pole. The power station will be at Chiswick, and will contain three-phase plant at 5,000 volts and 25 periods. Eight miles of distant line will be operated from a substation with static transformation from 5,000 to 350 volts, and then rotary conversion to 550 continuous volts. The rotaries will also act as balancers. At first the services on the conduit and trolley sections will probably be independent.

E. H. C.-H.

608. *Street Railway Trucks.* **W. H. Heulings, Jr.** (Street Rly. Journ. 15. p. 809, Nov., 1899. Paper read before the Pennsylvanian Street Rly. Association.)—Most of the destruction of street railway tracks comes from badly constructed and not from heavy cars. Destructive power of a car varies as the square of its speed. Tests made as the result of litigation at New Orleans proved that 22-feet cars on maximum traction trucks consume no more power than 18-feet cars on single four-wheel *trucks.* E. H. C.-H.

TELEGRAPHY AND TELEPHONY.

609. *Kamm's Zerograph.* (Electrician, 44. pp. 145–146, Nov. 24, 1899.)—This is a type-printing telegraph by L. Kamm, and is an improvement upon a similar apparatus brought out two years ago. A flat spring moves over a lever which presses against a pin on the synchronising arm and forces it forward as soon as the arm is released by depression of a key. The travel of this lever can be altered by adjusting a screw. Originally the depression of a key energised a starting magnet which released the synchronising arm; but this is now done away with, and the disengagement of the arm is effected mechanically, as is also the contact sending a current to line. As formerly, when the arm reaches a position corresponding to the key depressed, a second contact is made. Formerly this closed the circuit of a "second-contact magnet," whose function was to send a second current to line. Now also a second current impulse is sent to line, but the "second-contact" magnet is replaced by a light armature added to the printing magnet.

To have the maximum number of signs with the minimum number of keys, there are two types, one above the other, on each type spring; and there is a special key, as on some typewriters, to change from upper to lower case. Ordinarily the upper of the two types would be struck against the tape and ink ribbon when the printing magnet is energised; but, when the shifting key is depressed, the type quadrant rises by exactly the difference in height between the two types, and the second type comes into action. When the other shifting key is depressed, the type carriage, upon which is the quadrant, is restored to its former position. The maker claims that the effect of capacity and inductance on a long line is minimised by the extreme brevity of the current impulse. The apparatus is said to have been tried successfully between Berlin and Frankfort upon an iron telegraph wire, upon a metallic circuit between Paris and Rouen, and is on trial in the G.P.O. in London, where it has been worked on an underground cable to Leamington.

E. O. W.

REFERENCES.

610. *Farmers' Telephones.* (Elect. Rev. N.Y. 35. p. 159, September 6, 1899.)—A small exchange used by farmers who have clubbed together and are connected by one trunk to the nearest town. M. O'G.

611. *Modern Telephony.* **A. R. Bennett.** (Feilden, 1. pp. 320–336, Oct., 1899.—Describes some constructive requirements and switching systems for telephonic communications. J. E. K.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

MARCH 1900.

GENERAL PHYSICS.

2. *Viscosity*. **T. E. Thorpe.** (Roy. Instit., Proc. 15. pp. 641–660, 1899.) : author gives an account of the main results of the investigations on the ction between viscosity of liquids and chemical nature carried out by lf in collaboration with the late J. W. Rodger. An improved form of atus was used which enabled a series of successive measurements with ame liquid to be rapidly made without disturbing the apparatus in any .*i.e.*, for refilling, &c., as in the ordinary forms). For each liquid the ute viscosity-coefficients were determined at various temperatures, the atus being immersed in a water or glycerine bath, which was kept at a rm temperature by stirrers driven by a small turbine. A curve is given ing the viscosity of water at temperatures between 0° and 100° C., and in ction with this the author gives an interesting account of the various rmalities" exhibited by water, and how they can be explained by the nption of the existence of molecular complexes. A tabulated list is of the constants in Slotte's formula, $\eta = C/(1 + bt)^n$, for the various ances examined. The author then discusses the question as to what eratures are to be regarded as "corresponding" for the purpose of ng stoechiometrical deductions, and gives finally a list of *fundamental ity-constants* corresponding to equal values of $\frac{d\eta}{dt}$. From these it is ble to calculate values for the viscosities of most of the substances ined which are in very fair agreement with the observed values. F. G. D.

13. *Soap Emulsions*. **F. G. Donnan.** (Zeitschr. Phys. Chem. 31. pp. 42– Dec. 22, 1899.)—The author allows a definite volume of olive or rape flow from a pipette with a turned-up end through alkali solutions of ng strengths, and counts the number of drops formed in each case. In ase of the ordinary rape oil of commerce the number of drops increases the concentration of the alkali solution ; thus with water 88 drops are ied, whilst with a caustic soda solution containing 0·0011 gram-molecules itre the number of drops is 430. Similar behaviour is observed when m carbonate, borax, and other sodium salts which suffer hydrolytic iation in aqueous solution are employed. These results—as well as

LIGHT.

618. *Optical Constants and Dispersion oj Camphoı Derivatives.* **A. Haller** and **P. T. Muller.** (Comptes Rendus, 129. pp. 1005–1008, Dec. 11, 1899.) —The authors have determined the refractive indices, dispersions, and rotatory powers of a number of alkylcamphors obtained by the reduction of the compounds formed by the condensation of camphor with aromatic aldehydes. The results confirm the conclusion that the high values found for the physical constants in question in the case of these latter compounds are due to the presence of a double, or ethylenic, atomic linkage. N. L.

619. *Refractive Indices of Metals.* **E. van Aubel.** (Zeitschr. Phys. Chem. 30. pp. 565–566, Dec. 1, 1899.)—The refractive indices of a number of metals are here calculated from the refractive indices of salts of the metal, either in the solid state or in a state of solution. The values obtained are compared with Drude's experimental results, but there is no sort of agreement between them.

Kundt's theory, that the product of refractive index and electric conductivity of metals should be constant, does not at all agree with Drude's results, nor does it agree any better with the values of the refractive index calculated in this paper. J. B. H.

620. *Binocular Magnifying Glass.* **E. Berger.** (Comptes Rendus, 129. pp. 821–823, Nov. 20, 1899.)—Endeavours have been made to construct a binocular apparatus for the use of watchmakers and others which should have a low magnifying power and a large field of view. In his apparatus the author uses eccentric convex lenses, inclined to the line of view, so as to increase the angle of incidence and the prismatic effect of the lenses. The inclination of the lenses should be so chosen as to counteract any effect of astigmatism, either in the observer's eye or in the lenses themselves. E. E. F.

621. *Colour Photography.* **L. Vidal.** (Scientific American. 81. pp. 234–235, 1899.)—The paper, read before the Photographic Club of Paris, gives working details of a method of preparing photographic transparencies in natural colours. Three negatives are taken through three coloured screens, and from these positives are printed on bichromate-sensitised films. The positives are dyed with the complementary colours of the screens with which they were obtained, and superposed. Formulæ are given for the colouring solutions. G. H. B.

622. *Propagation of Light.* **J. Boussinesq.** (Comptes Rendus, 129. pp. 859–864, Nov. 27, and pp. 905–911, Dec. 4, 1899.)—A mathematical investigation of the propagation in a heterogeneous transparent medium of a lateral mited pencil of parallel light, the integration of the equations of moti ing given. In the second portion the author discusses the justification of t nciple of Fermat on the economy of time in the transmission of lumin ion across a heterogeneous medium which is also transparent a opic. These papers are a continuation of a previous one (Comp tus, 129. pp. 794–798, Nov. 20, 1899). J. J

623. *Polarisation Photometer.* **F. F. Martens.** (Deutsch. Phys. Gesell., Verh. 1. pp. 204-208, 1899.)—The working parts of this photometer are contained in a tube which can be turned about its axis, the angle being measured on a circular scale. The lights to be compared are admitted through two openings at the end of the tube and passed successively through an objective, a Wollaston prism, a biprism, an analysing Nicol, and two lenses forming a Ramsden's eyepiece. The instrument in some respects resembles the spectro-photometer of König, but important advantages are claimed for it as regards speed and certainty of working, due to the fact that the biprism and the Wollaston prism are adjustable at different angles, affecting the sensitiveness and speed of action. The adjustment for equality of the two halves of the field is effected by turning the analysing nicol through an angle indicated on one of the scales of the instrument. The instrument is so constructed that its working tube can be pointed in any direction, so that, for instance, the light coming from a particular part of the sky, or that from a luminous surface, can be examined with equal convenience. A brief description is given of five uses to which the instrument can be put: (1) Detection of the plane of polarisation of a source of plane polarised light; (2) Measurement of the proportion of polarised to nonpolarised light; (3) Measurement of candle-power; (4) Measurement of the rotating power of a liquid; (5) Measurement of the absorption power of a substance. W. E. S.

624. *Rotatory Power and Pressure.* **L. H. Siertsema.** (Archives Néerlandaises, 3. pp. 79-87, 1899.)—The results are given of experiments on the effect of pressure on the natural rotation of the plane of polarisation in solutions of cane sugar. The experiments are considered with reference to the hypothesis of Tammann as to the influence which internal pressure exercises on molecular properties. According to this theory the coefficient of variation of specific rotatory power when an external pressure is exerted should be the same as in the case of variation of internal pressure, and this last may be modified by the addition of sugar or any salt. The author concludes that in the variations which the specific rotatory power undergoes through pressure, change of concentration and the addition of an inactive salt, there are involved phenomena more complicated than the theory of Tammann is capable of explaining. J. J. S.

625. *Interferometer Study of Zeeman Effect.* **J. C. Shedd.** (Phys. Rev. 9. pp. 1-19, and pp. 86-115, 1899.)—The first portion contains an historical summary of the methods hitherto adopted, and an account of some preliminary experiments with Michelson's interferometer. The second part contains an account of the work done with the interferometer for the purpose of determining the relation, at different temperatures, of the magnetic displacement to the strength of field, and of measuring the displacement and determining the ratio e/m. The values obtained for the magnetic displacement show that any classification based upon this alone is of small value; but that a classification based upon the value of e/m gives groups of lines identical with Michelson's three types of lines. The complexity of structure also depends upon the value of e/m. The method adopted is similar to existing interferometer methods, but is claimed to be specially adapted to the problem attacked. E. E. F.

626. *Anomalous Dispersion.* **E. Aschkinass.** (Ann. d. Physik, 1. 1. pp. 42-68, Jan. 1900.)—The electromagnetic theory of dispersion leads to the

conclusion that anomalous dispersion must occur in the infra-red spectrum whenever the value of the refractive index for waves of infinite length, derived from Cauchy's formula by extrapolation, is not equal to the square root of the dielectric constant. This consideration was utilised by the author as a guide in the selection of substances in which anomalous dispersion might be expected. To discover this anomalous dispersion the author employs the method of multiple reflection. He thus found a number of anomalous dispersion bands in quartz, mica, fluorspar, marble, gypsum, alum, rock-salt, sylvine, and the bromides of sodium and potassium. Those in quartz occurred at 8·50, 9·02, and 20·75 μ, while that in potassium bromide occurred at the extreme region of measurable rays, between 60 and 70 μ. E. E. F.

627. *Chemical Action of Röntgen Rays.* **P. Villard.** (Comptes Rendus, 129. pp. 882–883, Nov. 27, 1899.)—Not only do Becquerel rays exert a well-defined chemical action (see 1899, Abstract No. 1144), but, as the author shows, Röntgen rays also exert a chemical action, not only upon photo-sensitive salts, but upon substances contained in some kinds of glass. He expresses this fact drastically by saying that radiographs can be obtained with simple glass plates instead of sensitive plates. The colouring action of Röntgen rays upon the tubes generating them is well known. The portion of the tube which lies in front of the plane of the antikathode takes a violet or brown tinge according to the composition of the glass. Villard encloses the antikathode in a wide tube, and protects the inner surface of the latter from the action of diffused kathode rays by a lining of aluminium foil. In that case only a violet colouring is produced, even in ordinary lead glass. On removing the aluminium lining the lead glass is coloured brown, owing to the oxidation of the lead by the diffused kathode rays. No colour is produced behind a platinum screen. The author proposes to make a silicate in which the reducing action should be more pronounced and apparent. E. E. F.

628. *Influence of Röntgen Rays upon Selenium.* **Perreau.** (Comptes Rendus, 129. pp. 956–957, Dec. 4, 1899.)—The author made the simple experiment of exposing a selenium cell to the action of an X-ray tube at a distance of 5 cm. Its resistance fell "rapidly" from 40,000 ohms to 34,000 ohms, and kept oscillating slightly about the latter value, owing probably to variations in the intensity of the rays. When the rays ceased, the cell regained its normal conductivity more slowly than it does after the impact of light. The reduction in the resistance was the same as would be produced by a gas-jet placed at a distance of 1·5 m. The action of the Röntgen rays diminished with increasing distance, but was still sensible at 17 cm. The author made sure that the effect was not due to secondary causes. Electric waves do not affect the resistance of selenium. E. E. F.

629. *Magnetic Deflection of Becquerel Rays.* **H. Becquerel.** (Comptes Rendus, 129. pp. 996–1001, Dec. 11, 1899.)—A small piece of radio-active barium, wrapped in aluminium foil, is placed in the centre of an iron disc forming one pole-piece of a strong electromagnet. The other pole-piece carri[es] a fluorescent screen. When the magnet is not excited a faint and wide[ly] dispersed luminosity is found on the screen. As soon as the magnet is excit[ed] the luminous area contracts and becomes more intense. It is immaterial h[ow] the magnet is excited, as a reversal of the poles does not affect the res[ult]. Sensitive plates show the increase of intensity very clearly. With a distan[ce] of 15 mm. between the pole-pieces, a strongly marked negative is obtained

[redacted]

a minute and a half. When the rays pass across the magnetic lines of force, and not along them, the rays, after proceeding upwards from the source, curve round like projectiles and impinge upon the plate along a curve extending from one pole to the other, and bending out of the way of the radiant substance in the centre. The properties described are analogous to those of kathode rays. E. E. F.

630. *Magnetic Deflection of Becquerel Rays.* **H. Becquerel.** (Comptes Rendus, 129. pp. 1205–1207, Dec. 26, 1899.)—The author describes some further interesting qualities of the rays named after him. It appears that their magnetic deflection is a property varying from one radiant preparation to another. Polonium preparations show no traces of deflected rays in the most powerful magnetic field, whereas radium preparations show very distinct magnetic deflection. This would point to the conclusion that the difference between Röntgen and Becquerel rays is, after all, a quantitative rather than a qualitative one, and absorption and magnetic deflection appear to go hand in hand. Another striking experiment described by the author is the following: A piece of radium preparation is placed in a uniform magnetic field, and a photographic plate near it with its plane normal to the lines of force. The result is "an intense impression, limited by a spiral whose sense is that of the current which produces the field." This spiral is the trace, deformed by the field, of the line of intersection of the vertical plate and the plate on which the radium rests. If it could be proved that the radiation transports charged particles which are deflected by an electrostatic field it would be possible to form an estimate of the velocity of the rays. But the experiments undertaken hitherto in this direction have not given any indication of electric deflection or electric charges. The curves obtained in the photographs show that the speed of propagation of radium radiation is of the order of the speed of rotation communicated by a magnetic field of about 4,000 units. If it is admitted that in a field in air of unit strength the speed of rotation of the magnetic whirls is $2\pi \times 6{\cdot}6 \times 10^5$ per second, the velocity of the radium rays comes out very near the velocity found for kathode rays.

E. E. F.

631. *Radio-active Substance emitted from Thorium Compounds.* **E. Rutherford.** (Phil. Mag. 49. pp. 1–14, Jan. 1900.)—Besides the ordinary radiation from thorium compounds, similar to that from uranium, it is found that they continuously emit radio-active particles of some kind, which retain their radio-active powers for some minutes. This emanation has the power of ionising the gas in its neighbourhood and of passing through thin layers of metals, and with great ease through considerable thicknesses of paper. The emanation gradually loses its radio-active power. It passes through a plug of cotton-wool without any loss of its radio-active powers. It is also unaffected by bubbling through hot or cold water, weak or strong sulphuric acid. In this respect it acts like an ordinary gas and differs from an assemblage of ions.

It is suggested that the emanation may possibly be a vapour of thorium, but on trial it was found that the amount of the emanation from thorium oxide was not sufficient to appreciably alter the pressure of the gas in an exhausted tube, and the spectrum of the gas was unchanged. The positive ion produced in a gas by the emanation was found to possess the power of producing radio-activity in all substances on which it fell. This power of giving forth a radiation lasts for several days. J. J. S.

632. *Phosphorescence Produced by Radiation from Radium.* **H. Becquerel.** (Comptes Rendus, 129. pp. 912–917, Dec. 4, 1899.)—Various substances were exposed to the action of the radiation given out by an active specimen of the chloride of barium containing radium. The materials used included hexagonal blende, platinocyanide of barium, diamond, double sulphate of uranium and potassium. The phosphorescence produced varied in the different cases. When screens of different nature were interposed between the radiating source and the phosphorescent bodies it was found that there was an absorption relatively unequal by the same screen of the radiation which excited the phosphorescence of the different substances. It seems that each substance is excited by a particular radiation, and it may be concluded that radiations of different nature proceed from the radiating source, which are characterised by their absorption, and are analogous to the radiations of different wave-length from a beam of white light.

In certain minerals there is a considerable persistence of the phosphorescence excited by radium.

A large number of bodies when exposed to the influence of radium acquire a temporary power of rendering the air conducting and can discharge electrified bodies at a distance. These facts afford new proofs of the reality of a continuous emission of energy by radio-active bodies. They show, moreover, the existence in this emission of particular radiations characterised by their selective absorption. J. J. S.

633. *Chemical Effect of Becquerel Rays.* **P.** and **Mme. Curie.** (Comptes Rendus, 129. pp. 823–825, Nov. 20, 1899.)—The rays emitted by very active radiant salts of barium are capable of transforming oxygen into ozone. When the salts are kept in a stoppered bottle, the smell of ozone is perceived on opening it. This was first observed by Demarçay. Potassium iodide paper is coloured blue. It is only the luminous radio-active preparations which produce this effect, but it is more the radio-activity than the luminosity which is effective, since highly luminous preparations are often less chemically active than those of inferior luminosity. Another chemical effect produced is the violet colouration of the glass in contact with the salt. The violet colour gradually penetrates the glass, and deepens in shade, finally becoming nearly black. There is also an effect of the rays upon barium platinocyanide screens, which gradually turn yellow and brown under their influence and lose their power of fluorescence. But this is immediately restored by exposure to sunlight. Of all these effects the production of ozone is the most significant, as it implies a continuous expenditure of energy.

E. E. F.

REFERENCE.

634. *Diffused Reflection of Light on Matt Surfaces.* **H. R. Wright.** (Phil. Mag. 49. pp. 199–216, Feb., 1900; also Ann. der Physik, 1. 1. p. 17, 1900.)—Paper referred to in Abstract No. 462 (1900).

HEAT.

635. *Thermal and Dynamic Coefficients.* **J. E. Trevor.** (Journ. Phys. Chem. 3. pp. 573–576, Dec. 1899.)—In a former paper (see 1900, No. 71), the author considered the four thermodynamic coefficients, p, v, θ, η, which are connected by two independent relations, namely, $f(p, v, \theta) = 0$, and $\phi(\eta, v, \theta) = 0$. From these he formed four derived functions, E, F, G, H, of which E, the energy, satisfies the equation—

$$dE = -p dv + \theta d\eta.$$

These four are called the fundamental functions. In the former paper p, v, θ, η, and their derivatives, were expressed as partial derivatives of E, F, G, H. It appeared that these derivatives fell in a remarkable way into three groups. In the present paper he explains why this is the case.

Using—

$$dE = -p dv + \theta d\eta,$$

and—

$$\left.\begin{aligned} dp &= \frac{\partial p}{\partial v} dv + \frac{\partial p}{\partial \eta} d\eta \\ d\theta &= \frac{\partial \theta}{\partial v} dv + \frac{\partial \theta}{\partial \eta} d\eta \end{aligned}\right\}$$

he finds twelve derivatives of E in three groups, namely, (1) Second derivatives; (2) Ratios of second derivatives; (3) Ratios of second derivatives to the Hessian. S. H. B.

636. *Deviation from Boyle's Law in Mixtures of Hydrogen and Carbon Dioxide.* **J. E. Verschaffelt.** (Zeitschr. Phys. Chem. 31. pp. 97–102, Dec. 22, 1899.)—According to the theory of van der Waals the characteristic equation for a mixture of gases may be put in the same form as for a simple gas, the constants a_x and b_x having, for each molecular fractional composition x, values which are quadratic functions of the values of a and b for the pure gases. The experimental information is hardly sufficient to distinguish the parts played by a and b in the equation separately, but for large volumes it takes the form—

$$pv = RT + \frac{RT\, b_x - a_x}{v} = RT + \frac{m}{v},$$

where the "normal" volumes (*i.e.*, volumes at 0° and 1 atmo.) are taken as unity. If instead of this we take the "theoretic" volume (v'), *i.e.*, the volume the gas would occupy at 0° and 1 atmo. according to Avogadro's law if it were a perfect gas, we have $pv' = RT$, and hence—

$$pv - \frac{m}{v} = pv'.$$

Now for hydrogen Amagat finds $b = 0{\cdot}00069$, $a = 0$: for carbon dioxide van der Waals finds from Regnault's data $a = 0{\cdot}00874$, $b = 0{\cdot}0028$; whence $m = -0{\cdot}00644$.

An observation by Braun on the increase of pressure of a mixture in equal volumes of hydrogen and carbon dioxide—amounting to 0·0014 of the total—may be expressed according to the quadratic formula by taking—

$$0{\cdot}99931 + 0{\cdot}0060\,(1 - x)^2$$

as the deviation from the law of Arogadro. The author has made experiments '(Proefschrift, Leiden, 1899) on the isothermals of the mixed gases at 18° between $v = \infty$ and $v = 0{\cdot}01$ expressible by the formula—

$$pv = \mathrm{RT} + \frac{m}{v} + \frac{n}{v^2}$$

where the larger coefficient m agrees very closely with the quadratic function

$$m = 0{\cdot}00074\, x^2 - 0{\cdot}0012\, x\,(1-x)^2 - 0{\cdot}0063\,(1-x^2)$$

deduced from Braun's observation. R. A. L.

637. *Comparison of Platinum and Gas Thermometers.* **J. A. Harker** and **P. Chappuis.** (Roy. Soc., Proc. 65. pp. 327-329, 1899.)—In the words of the original, "The present paper is the outcome of the co-operation of the Kew Observatory Committee and the authorities of the International Bureau of Weights and Measures at Sèvres, for the purpose of carrying out a comparison of some platinum thermometers with the recognised international standards.

"A new resistance-box, designed for this work, and special platinum thermometers together with the other accessories needed were constructed for the Kew Committee, and after their working had been tested at Kew, were set up in the laboratory at Sèvres in August, 1897. The comparisons executed between these instruments and the standards of the Bureau may be divided into several groups. The first group of experiments covers the range —28° to 80°, and consists of direct comparisons between each platinum thermometer and the primary mercury standards of the Bureau. Above 80° the mercury thermometers were replaced by a gas-thermometer constructed for measurements up to high temperatures. The comparisons between 80° and 200° were made in a vertical bath of stirred oil, heated by different liquids boiling under varying pressures. For work above 200° a bath of mixed nitrates of potash and soda was substituted for the oil tank. In this bath comparisons of the two principal platinum thermometers with the gas-thermometer were made up to 460°; and with a third thermometer, which was provided with a porcelain tube, we were able to go up to 590°. Comparisons of the platinum and gas-scales were carried out at over 150 different points, each comparison consisting of either ten or twenty readings of the different instruments.

"By the intermediary of the platinum thermometers a determination of the boiling-point of sulphur on the nitrogen scale was also made. The mean of three very concordant sets of determinations with the different thermometers gave 445·27° as the boiling-point on the scale of the constant volume nitrogen thermometer, a value differing only 0·7° from that found by Callendar and Griffiths for the same temperature expressed on the constant pressure air scale.

"If for the reduction of the platinum temperatures in our comparisons we adopt the parabolic formula, and the value of δ obtained by assuming our new number for the sulphur-point, we find that below 100° the differences between the observed values on the nitrogen scale and those deduced from the platinum thermometer are exceedingly small, and that even at the highest temperatures the differences only amount to a few tenths of a degree."

R. A. L.

638. *Surfusion.* **R. Moreschini.** (Accad. Lincei Atti, 9. pp. 13–16, Jan. 7, 1900.)—Mixtures of fatty acids obtained from soap exhibit the phenomenon of surfusion, the point of solidification varying with the method of determination used. When such a mixture, placed in a tube surrounded by a constant temperature air-bath (conveniently 15° below the melting-point), is heated to, say, 15° above its melting-point and then allowed to cool, the rate of cooling diminishes regularly as the temperature falls until the melting-point is nearly reached, when a sudden diminution occurs; cooling afterwards proceeds regularly, although more slowly than before. It is found that this behaviour is also shown by other bodies capable of existing, permanently or temporarily, in a state of surfusion. In the case of pure substances, however, the change occurs just at the melting-point, whilst with mixtures of fatty acids, especially if much oleic acid is present, it appears at a temperature slightly (about 0·15°) above the melting-point. T. H. P.

639. *Colours of Heated Steel Corresponding to Different Degrees of Temperature.* **M. White** and **F. W. Taylor.** (Indus. and Iron, 27. p. 398, Dec. 15, 1899. Paper read before the American Society of Mechanical Engineers.)—Estimations of the temperature of heated steel by the eye vary considerably with different observers and with the quality or intensity of the light in which the observations are made, but from a number of experiments with the Le Chatelier pyrometer the following colour scale is considered as best suited to the conditions met with in most workshops. The temperatures are given in degrees Fahrenheit. Dark blood red, black red, 990°; dark red, blood red, low red, 1,050°; dark cherry red, 1,175°; medium cherry red, 1,250°; full cherry red, 1,375°; light cherry, bright cherry, scaling heat, light red, 1,550°; salmon, orange, free scaling heat, 1,650°; light salmon, light orange, 1,725°; yellow, 1,825°; light yellow, 1,975°; white, 2,200°. N. L.

640. *Change of Thermal Conductivity on Melting.* **E. van Aubel.** (Zeitschr. Phys. Chem. 30. pp. 563–564, Dec. 1, 1899.)—Some substances show no noticeable change on melting, but ice shows a very large change, having the value 0·30 a little below zero while water has 0·0722 at 0°. R. A. L.

REFERENCE.

641. *Thermal Expansion of Nickel and Cobalt.* **A. E. Tutton.** (Roy. Soc., Proc. 65. pp. 306–312, 1899.)—Contains numerical data of the experiments referred to in Abstract No. 1488 (1899). R. A. L.

ELECTRICITY.

642. *Luminosity of Gases under Discharge.* **J. Stark.** (Ann. d. Physik, 1. 2. pp. 424–429, Feb., 1900.)—Wiedemann has shown that the temperature of a gas showing the ordinary vacuum phenomena is in general below 100°. He concluded that the luminosity is not a phenomenon of incandescence, but of phosphorescence. This conclusion has since been corroborated, but the experiments are complicated by the fact that the introduction of a hot body in itself reduces the discharge potential and increases the current through the tube. The author introduces independent carbon filaments into the tube and heats them to white heat by a current, a red heat producing no effect. He finds that if the filament is in the region of positive light it reduces or extinguishes the light. If it is stratified the filament cuts pieces out of the bright strata. A short positive column is totally extinguished by the filament. The negative light is enfeebled, but the luminescence of the walls is unaffected, thus showing that the kathode rays remain uninfluenced. The heating simply deprives the gas of its power of phosphorescence under discharge. Knowing that a rarefied gas is ionised by heating, we must conclude that an ionised gas does not phosphoresce under the influence of the discharge. This, again, indicates that the phosphorescence is a molecular phenomenon. E. E. F.

643. *Revision of Electrical Units.* **R. A. Fessenden.** (Electrician, 44. p. 336, Dec. 29, 1899.)—The author has discovered a way of eliminating 4π from the formulæ defining electric units without changing any of the legal units. It consists simply in taking the magnetic permeabilities of the ether as $(4\pi)^2$ instead of unity. This produces no change in the units of current and voltage. The unit of difference of magnetic potential becomes 4π times as large as the former unit. The new unit is in fact the ampere-turn, which is already used in practice. The distinction between magnetic or electric flux and quantity disappears, and with it no less than twenty-six separate and distinct terms.

The author also proposes a new nomenclature for the absolute electromagnetic and electrostatic units, which should be used instead of the "practical" units. The unit of difference of electric potential should be the Volma or Volsta, in the electromagnetic and electrostatic system respectively. Further, the author has designed a system of suffixes to denote space, area, volume, and time differentials. E. E. F.

644. *Resistance and Residual Charge of Liquid Dielectrics.* **A. Naccari.** (Accad. Sci. Torino, Atti, 34. 15*a*. pp. 820–833, 1898–99.)—Experiments on xylol, toluol, benzol, and various petroleums show that rise of temperature produces an increase of conductivity of the same order as that in electrolytes, and greater in proportion to the original resistance. In dielectrics of high resistivity the residual charge is also high. It diminishes with increasing temperature, but not in proportion to the diminution in the resistance. Residual charges are possibly due to some lack of homogeneity in even a simple liquid. E. E. F.

645. *Internal Resistance of Daniell Cell.* **E. Cohen.** (Zeitschr. Phys. Chem. 31. pp. 164–175, Dec. 22, 1899.)—This paper starts with the description of an electrical method of determining the temperatures at which internal changes take place in saturated solutions. The method is similar to that used by Dawson and Williams (see 1900, Abstract No. 240). It is here applied to the case of a Daniell cell to test whether the temperature-coefficient of internal resistance is constant.

A curve is given for the resistance of a saturated solution of $CuSO_4 . 5 H_2O$. This curve consists of two straight lines meeting at an angle at about 56° C. The temperature-resistance curve of a 5 per cent. solution of $ZnSO_4$ is approximately a straight line near 56° C. The temperature-resistance curve of a Daniell's cell (which is the sum of the ordinates of the above two curves) must therefore have an angular bend at about 56° C. J. B. H.

646. *E.M.F. of the Clark Cell.* **H. S. Carhart** and **K. E. Guthe.** (Phys. Rev. 9. pp. 288–293, Nov.–Dec., 1899.)—The E.M.F. was determined absolutely in terms of the P.D. of a known current through a known resistance. The value of the current was found by the form of electrodynamometer used by Patterson and Guthe in the determination of the electrochemical equivalent of silver (see 1899, Abstract No. 1727). The final result for the E.M.F. of a Kahle H-form, set up according to the specification legalised by Congress in 1894, is 1·4333 volts at 15°. If 0·0011187 be taken as the silver equivalent for a solution not neutralised by silver oxide, and the figure obtained by Glazebrook and Skinner in 1892, viz., 1·4342 volts, be recalculated, it becomes 1·4332 volts at 15°, which is practically identical with the above. W. R. C.

647. *Measurement of Induction by Voltmeter.* **H. N. Allen.** (Electrician, 44. pp. 108–109, Nov. 17, and 191–193, Dec. 1, 1899.)—The self-induction of an alternate current circuit can be determined by the use of a voltmeter and ammeter from the formula $E = C\sqrt{R^2 + p^2 L^2}$ provided there is no mutual induction between the circuit and the voltmeter leads. With a closed circuit this is easily ensured by carrying the voltmeter leads close together for some distance from the circuit. With a portion only of a circuit, to eliminate mutual induction the voltmeter leads must be carried along the line along which the line integral of the vector potential due to the main current is zero. This can only be determined in two or three simple cases. By solving the differential equation for an alternating E.M.F., the error is calculated in terms of induction coefficients for electrodynamic and hot wire voltmeters, and in terms of capacity and induction for electrostatic instruments. These results are compared with observations of voltage across a single bar of a drum armature. With a frequency of 213 $\sim$, the true value being 0·22 volts, readings ranging from 0·11 to 0·34 were obtained by carrying the leads along various paths according to whether the E.M.F. generated in the voltmeter leads by mutual induction assisted or opposed the main voltage. L. B.

648. *Measurements on High-Pressure Circuits.* **L. Schüler.** (Elektrotechn. Ztschr. 20. pp. 868–869, Dec. 14, 1899.)—The author describes the recently patented method of measuring P.D., current, and power on high-pressure circuits used by the Elektricitäts A.—G. It consists in using either a whole armature coil (if the number of poles is large) or part of one (if the number of poles is small) for purposes of measurement, this "measuring coil" being entirely disconnected from the main armature circuit. The coil is joined in

series with a transformer whose ratio of transformation is unity, and whose secondary is inserted into the main circuit of the machine. A voltmeter connected across the terminals of the "measuring coil" reads a definite fraction of the high P.D.; an ammeter in its circuit reads the high-pressure current; and a wattmeter in the same circuit reads a definite fraction of the total power developed by the machine. A. H.

649. *Determining Faults in Dynamos.* **K. Richter.** (Elektrotechn. Ztschr. 21. pp. 38-42, Jan. 11, 1900.)—After discussing a bridge method of testing for faults in the armature and field-magnet windings of dynamos described by O. Frölich in a paper read before the Elektrotechnische Verein on the 20th of December, 1892 (see Elektrotechn. Ztschr. Heft 4, 1893), the author describes a method which he has devised and which has yielded satisfactory results in practice. This method consists in observing the fall of potential along a linear conductor of constant specific resistance which is traversed by the current, and indicating the results of the observations in the form of a potential line, *e.g.*, in testing for a fault in the armature of a dynamo one terminal of a battery is connected to the armature shaft or core and the other to a point in the winding; a shunt circuit containing a high resistance galvanometer is then connected at one end to a fixed point in the winding and the other end moved from point to point throughout the winding to find the point or points of maximum or zero potential, as the case may be. When these points are found, the position of the fault can be easily determined. The various cases arising in practice are fully discussed mathematically by the aid of diagrams. C. K. F.

650. *Resistances.* **Feussner.** (Elektrotechn. Ztschr. 20. pp. 611-613. Discussion, pp. 613-614, 1899. Paper read before the Elektrotechnische Verein, Berlin, April 25, 1899.)—The ordinary resistances, consisting of silk-covered wire, will not stand high pressures or even a moderate dissipation of energy without danger to their insulation. Their capacity is also considerable. To overcome these difficulties the author uses thin, bare, flat strips of high-resistance metal, as small as 0·03 mm. wide, wound on mica sheets 0·2 to 0·3 mm. thick, and held in place by varnish. Bifilar winding is impossible, as it brings the ends of a coil with the full voltage across them too near together. Such coils are practically inductionless and without capacity, and will stand a dissipation of energy up to 40 watts per square decimeter. The method of flattening the fine wire is described. Resistance boxes for various purposes and voltages up to 10,000 are illustrated. This form of resistance has been in use satisfactorily for some years at the Reichsanstalt and the Weston Company's works. A discussion followed. L. B.

651. *A Speaking Galvanometer for Warships.* (Electrician, 43. p. 919, 1899.)—As the siphon recorder is too delicate, and the mirror instrument requires too much skill to read, Sullivan uses a balanced d'Arsonval galvanometer, which is damped by pressing a camel's hair on the suspension; this gives damping which only breaks down when the current reaches a certain value; at the same time the damping due to a short-circuited coil in the field is diminished by making the short circuit through a platinum wire. No condenser or sending switch is necessary. An "Instruction" galvanometer is made, by which teachers can imitate the signals in long and short cables by altering the position of the camel-hair brush and using a coil with large magnetic damping. M. O'G

652. *Vacuum Electroscope.* **H. Pflaum.** (Ann. d. Physik, 1. 2. pp. 290–293, Feb., 1900.)—The author produces a vacuum electroscope in the form of a pear-shaped bulb containing aluminium leaves attached to a thick aluminium wire, which projects outside the bulb and ends in a knob like that of an ordinary electroscope. In a good vacuum the leaves act more promptly and decisively than in air at ordinary pressures. The deflections are accompanied by a radiation of the electric charge on to the glass walls, which is, however, not accompanied by any luminosity. E. E. F.

653. *Frequency Meter.* **E. Stöckhardt.** (Elektrotechn. Ztschr. 20. pp. 873–874, Dec. 14, 1899.)—The principle of the instrument is identical with that of the Campbell Frequency Teller. An electromagnet whose coil is traversed by the alternating current is placed between the prongs of a rigidly fixed tuning-fork of wrought iron, and along the prongs may be slid simultaneously two riders which alter the period of the fork. The riders are provided with pointers moving along a scale, and they are moved by turning a cylinder to which are attached two fine wires connected to the riders. On the other side another couple of wires attached to the riders are coiled round another cylinder provided with a spring which tends to turn the cylinder so as to pull back the riders to the bend of the fork. The instrument is said to be very sensitive and to give a sharp maximum of sound. A. H.

654. *Graphical Treatment of Distorted Wave-Forms.* **R. Goldschmidt.** (Elektrotechn. Ztschr. 20. pp. 840–842, Nov. 30, 1899.)—The author explains a graphical method of finding the current-wave in an inductive circuit produced by an E.M.F. wave of irregular shape, without the necessity of having recourse to harmonic analysis. The method is an approximate graphical integration of the differential equation of current, and is based on the assumption that the E.M.F. wave consists of a broken straight line instead of a continuous curve. A. H.

655. *Resistance of Conductors to Alternating Currents.* (Ind. Élect. 8. pp. 556–557, Dec. 25, 1899.)—The author gives an approximate method of calculating the resistance of a cylindrical conductor to alternating currents which does not directly involve the resistivity of the material. Let $R_c =$ resistance of given conductor to continuous currents; $R_a =$ resistance of given conductor to alternating currents; $l =$ length of conductor, in kilometres; $p = 2\pi \times$ frequency; $a = \frac{pl}{R_c . 10^4}$, and $b = \frac{0\cdot2\pi}{p} \cdot \frac{R_c}{l} \cdot 10^4$. Then—

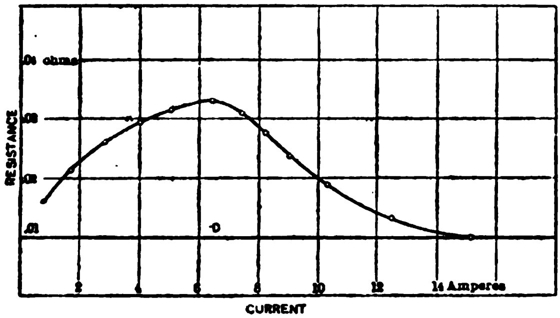
$$R_a = kR_c,$$

where, for values of $a > 25$, we may take $k = 0\cdot25 + \sqrt{\frac{a}{2}}$; for values of $a < 1$, $k = 1 + \frac{a^2}{12} - \frac{a^4}{180}$; and for values of a lying between 1 and 25, k is given by a table, part of which is here reproduced.

$a =$	1	2	4	6	8	10	16	20	25
$b =$	6·283	3·142	1·571	1·047	0·7854	0·6283	0·4488	0·3142	0·2513
$k =$	1·078	1·265	1·678	2·007	2·274	2·507	3·095	3·415	3·735

A. H.

656. *Resistance of Iron Wires to Alternating Currents.* **E. Merritt.** (F Rev. 9. pp. 294–299, Nov.–Dec., 1899.)—If iron wires are used to c alternating currents, the resistance of the wire depends upon the frequ of the current and the permeability of the iron, in addition to the ler cross-section, and temperature. As the permeability depends upon intensity of magnetisation, the resistance to heavy currents may be less to moderate currents, even though the temperature is greatly increa



This is shown in the curve given above, which was obtained experimen by H. H. Denis, at the author's suggestion, with a wire 0·866 cm. in diam with an alternating current of frequency about 130 periods per second. curve A shows the resistance offered to the alternating current, whilst curve D shows the variation in resistance with current strength by usi direct current. The test was carried out by the Wheatstone Bridge met a telephone being used for alternating currents. W. C

657. *Magnetic Properties of Iron-Aluminium Alloys.* **S. W. Richard** (Phil. Mag. 49. pp. 121–154, Jan., 1900.)—The author determines ex mentally the curves connecting the magnetising force and the mag induction in alloys of iron and aluminium over a range of temperatur — 83° C. to + 900° C.

The specimens tested contain respectively 3·64, 5·44, 9·89 and 18·47 cent. of aluminium. The method of test was the use of a ballistic galv meter and a secohmmeter. The specimens, which are in ring form, wound with two coils, the secondary being of platinum, whose resis is taken as a measure of the temperature. The chief results may be marised as follows: (1) The alloys behave magnetically as though consisted of two distinct media superposed. (2) The general roundne the curves and their lack of abruptness near the critical point seem t dicate that the alloys are heterogeneous in structure. A similar lac abruptness is noticeable in Hopkinson's curves for nickel-iron alloys. (3) permeability decreases with rise of temperature near the critical point a minimum value is reached, when any further rise of temperature prod very slight diminution, if any, in the permeability. (4) The experi suggest that the maximum value of the permeability for an alloy conta 10 per cent. of aluminium is reached at about — 90° C. (5) An allo taining 18·47 per cent. of aluminium has a critical point at about 25° gives no indication of temperature hysteresis. This alloy probabl maximum permeability at a temperature much below — 90° C. V

658. *Magnetism of Bricks.* **O. A. Gage** and **H. E. Lawrence.** (Phys. Rev. 9. pp. 304–309, Nov.-Dec., 1899.)—The authors tested the magnetism of a number of bricks (at least thirty-two) of various qualities. All but one—nearly white—were found to be magnets. The poles were never in the ends of the bricks, but either in the faces or edges. The magnetic moments of the bricks were not constant, but varied from time to time, when kept under normal conditions. Heating temporarily diminished the magnetic moments. It is surmised that the magnetism is due to the presence of magnetic iron oxide, either as a component of the clay or developed by heat, and that the permanent magnetism arises from the cooling of the bricks in the earth's magnetic field. The positions of the poles may be explained by the way the bricks are laid in the kiln. A. G.

659. *Magnetic Elements in Northern Italy.* **E. Oddone.** (Accad. Sci. Torino, Atti, 34. 15*a*. pp. 799–819, 1898–99.)—Measurements of declination, dip, and intensity were carried out in 1898 in the districts of Feletto and Rivarolo Canavese, at a time free from magnetic disturbances. They yielded an important correction of the course of the isoclinic lines on the Italian charts. Thus the isoclinic 62·0° should run north of the stations mentioned, and not south. E. E. F.

660. *Magnets Used in the Determination of the Earth's Horizontal Magnetic Force.* **C. Chree.** (Roy. Soc., Proc. 65. pp. 375–418, Nov. 30, 1899.)—The values of the constants (temperature coefficient, induction coefficient, moment of inertia and distribution correction) of over a hundred collimator magnets of the Kew pattern have been determined at Kew Observatory, and in the present paper the author discusses the values obtained. The temperature coefficient is determined from observation at 0°, 18°, and 36° C., and the numbers obtained support the correctness of the parabolic formula employed for calculating the magnetic moment at any temperature for the magnetic moment at 0°. Attempts were made to deduce relations between the values of the different "constants," but they were not very conclusive, partly no doubt owing to the fact that the dimensions of the magnets are not recorded.

The author also discusses the probable errors introduced into the determination of the horizontal component owing to the possible errors which exist in the values of the "constants." In particular the effect of errors in the value assumed for the distribution constant (P), and also the approximations used in applying the correction for this are discussed, with the result that it is shown that a very appreciable error may easily be introduced on this account.

From a discussion of the observations made with the Observatory unifilar, the author concludes that the centre of the deflection bar is not vertically below the point of suspension of the fibre which carries the deflected magnet, and he discusses the effect of this asymmetry on the value obtained for H. W. W.

MEDICAL ELECTRICITY.

661. *Death by Electricity.* **R. H. Cunningham.** (Elect. World and Engineer, 34. pp. 1003–1004, Dec. 30, 1899.)—This may be called a "popular edition" of an article published in the New York Medical Journal of October 21 and October 28. It is the account of a series of experiments carried out to ascertain the mechanism of death by electricity.

Stated very briefly, and nearly in the author's own words, the conclusions are as follows: When the chest is traversed by a certain number of amperes, or fraction of an ampere, for a sufficient length of time, the most important effect produced is the immediate cessation of the co-ordinate beat of the heart. Consequently the circulation of the blood throughout the body ceases, and the various delicate nerve cells of the central nervous system die rapidly from the lack of indispensable blood. The action of the current upon the heart is clearly a physiological one, and the state produced in it is what physiologists term "fibrillation." Roughly speaking, in this condition the rhythmical synchronism of the contractions of the little muscle bundles of which the heart is composed is profoundly disturbed, and the contractions of the bundles fall out of phase. Thus the heart fails as a blood-pump, and death quickly ensues unless the circulation is restored.

The higher mammalia practically never recover spontaneously from this condition of fibrillation, but the lower the order of the animal the more likely is it to recover. Thus when guinea-pigs, rats, mice, turtles, frogs, and fish are subjected to strong currents, the permanency of the cardiac effects is less pronounced.

Owing to the small size of such animals, it is practically impossible to prevent a large part of the current from traversing the nervous system; and it is upon the latter that the physiological effect of the current chiefly falls. The result is then identical with that produced by passing the current only through the brain and upper part of the spinal marrow of a dog in such a fashion as not to include the heart in the circuit. When passed in this way through the brain comparatively weak currents (1 to 2 amperes) usually produce a more or less pronounced stoppage of the rhythmical respiratory movements during the time the current is passing. When the circuit is opened this so-called inhibitory effect passes off in a moment, and breathing becomes re-established. With very strong currents (6 to 12 amperes), usually one or more general convulsions follow the powerful stimulation of the cortex of the brain, and the respiratory inhibition is more pronounced; and if it persists long enough death results from asphyxia. If the latter be not too profound the animal can be restored by artificial respiration. When the circuit includes both brain and heart the effect is, of course, a combined one.

The author does not consider that consciousness is lost synchronously with the beginning of the shock, although the period of consciousness may be extremely brief. No reliable data can be given as to the minimum intensity of current necessary to produce cardiac fibrillation in man. Probably physiological susceptibility to the current varies. The 110-volt lighting current seems capable of electrocuting certain individuals. W. S. H.

662. *E.M.F's. of Muscle, from the Point of View of Diagnosis.* **M. Mendelssohn.** (Archives d'Él. Médicale, 8. pp. 1–18, Jan., 1900.)—The author has repeated the experiments of Hermann and others upon the E.M.Fs. developed in a muscle during its contraction, and applies them to the study of various paralytic conditions. He finds the most promising results in the examination of the diphasic wave of electromotive force which is set up in a muscle when its nerve is artificially stimulated. In a paralysed muscle the diphasic E.M.F. may cease to be proportionate to the degree of voluntary power which survives. In a muscle paralysed but preserving its electrical irritability the two phases are evident, and are still seen even when there is

atrophy of the muscle fibres. A notable decrease in the second phase in a paralysed muscle is a sign of approaching degeneration. In certain cases of atrophic paralysis a total disappearance of the second phase may be observed.

H. L. J.

REFERENCES.

663. *Thermoelectric Measurements.* **P. Straneo.** (N. Cimento, 10. pp. 269–276, 1899.)—Mathematical paper showing how, by a combination of the methods described in the *Lincei Atti* during two years past with the suggestions of Peterson in his inaugural dissertation *Ueber die Messung des Thomsonschen Effektes* (Zurich, 1895), it is possible to obtain accurate measurements of all the data required. The paper does not lend itself to abstracting. A. D.

664. *Magnetism of the Earth.* **Wessely.** (Archiv. Math. Phys. 17. pp. 116–117, 1899.)—A note on the earth's magnetism, as deduced from the earth's electrostatic change (calculated from the fall of potential in atmospheric electricity) taking into account the earth's motion. J. J. S.

665. *Plane Magnetisation of Pyrrhotine.* **P. Weiss.** (Soc. Franc. Phys., Séances, 2. pp. 87–90, 1899.)—Similar to paper referred to in Abstracts No. 713 (1899) and No. 525 (1900).

666. *Minimum Charging Current of a Condenser.* **A. Russell.** (Electrician, 44. p. 333, Dec. 29, 1899.)—This paper describes a graphic method of proving that the triangular form of P.D. wave is the one which produces the smallest effective current in charging a condenser to a given potential in a given time. J. B. H.

667. *Invention of the Coherer.* **C. Olivetti.** (Elect. World and Engineer, 34. pp. 858–859, Dec. 2, 1899.)—The invention of the coherer is claimed for T. C. Onesti in preference to Branly.

668. *Alternate Current Measurements.* **O. de Bast.** (Assoc. Ing. Él., Liège, Bull. 10 pp. 271–296, 1899; and 311–345, Jan., 1900.)—Elementary theoretical articles dealing with the principles underlying the measurement of current, voltage, and power, with a reference to various instruments used for these purposes.

669. *Radiographic Installation of the Val-de-Grace Military Hospital.* **E. Loison.** (Archives d'Él. Médicale, 8. pp. 20–29, Jan., 1900.)—A detailed description.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

670. *Velocity of Reaction in Heterogeneous Systems.* **H. Goldschmidt.** (Zeitschr. Phys. Chem. 31. pp. 235–249, Dec. 22, 1899.)—The velocity of saponification of ethyl acetate by hydrochloric acid and by baryta was measured in systems consisting partly of aqueous, partly of benzene solutions, in order to test the applicability of the law of mass action to such heterogeneous systems. Previous attempts in the same direction had been on solutions in contact with solid, but led to questionable results because saturation of a solution by solid is a slow process. Partition of a dissolved body between two solvents is much more rapid, so that the normal course of the reaction is less interfered with. For a monomolecular reaction this law of mass action leads to the same result as for a homogeneous system, except that the velocity is multiplied by $\frac{v_2 + v_1 C}{v_1 C}$ where v_1, v_2 are the volumes of the active solution (dilute acid) and neutral (benzene) respectively, and C the ratio of partition. This result was approximately verified for saponification by acid, but it is noted that on account of the insolubility of water in benzene, the concentration of ethyl acetate in it is large (for $\frac{\text{acid} \times \text{alcohol}}{\text{ester} \times \text{water}} = \text{constant}$)' hence the reaction becomes practically a reversible one. By allowing for this much more constant values were obtained for the reaction constant, and the applicability of the law of mass action satisfactorily proved. The trimolecular reaction studied gave similar results. R. A. L.

671. *Partial Association of Liquid Molecules.* **J. J. van Laar.** (Zeitschr. Phys. Chem. 31. pp. 1–16, Dec. 22, 1899.)—Assuming, from Ramsay and Shields' results, that water, alcohol, &c., consist partly of simple molecules, partly of molecules Θ times as large, the equilibrium expressed by

$$(H_2O)_\Theta \rightleftarrows \Theta \,.\, H_2O$$

exists, and the reaction constant K may be calculated as a function of the degree of dissociation β in the usual way. The heat of dissociation is then a function of β, and, if $\frac{\delta \log K}{\delta\beta}\,\frac{d\beta}{d\tau}$ (τ = temperature) is small enough to neglect, may be calculated. Assuming that for water $\Theta = 2$ the author finds from Ramsay and Shield's values of the factor of association at different temperatures, that the heat of dissociation is 1980 cal. per 18 gms., for the range 0°–100°. At higher temperatures the value found increases—a result that is supposed to be due to the increasing inaccuracy of the assumption made, and of the experimental data. Ethyl alcohol is also found to consist of double molecules. Methyl alcohol must contain molecules of mass $3\,CH_3OH$: it gives more divergent results, which are perhaps attributable to a progressive dissociation into $2\,CH_3OH$ and finally CH_3OH.

In a mixture of alcohol and water the volume must be a function of the degree of association of the two substances. By assuming that the specific volume of simple and double molecules of each substance is the same in the mixture as in the pure state, and neglecting minor terms, consideration of the densities of dilute solutions of water in alcohol and of alcohol in water le

to the conclusion that 1 mol. (18 gms.) of water expands 8·44 c.c. on passing into the associated condition: 1 mol. (46 gms.) of alcohol 2·0 c.c. Using these numbers and the known association factor, it becomes possible to calculate the specific volumes of the simple and double molecules separately. The abnormal volume changes of water at low temperatures may be accounted for by supposing that the contraction due to breaking up of molecular complexes compensates for the expansion due to heat; if this be done, the coefficient of expansion for water in the form of simple molecules is found as 0·000953 at 0° in agreement with the mean of five other liquids that have nearly the same critical point. R. A. L.

672. *Pseudo-Equilibria.* **M. Bodenstein.** (Zeitschr. Phys. Chem. 30. pp. 567–569, Dec. 1, 1899.)—This is a reply to Duhem's criticism (see 1900, Abstract No. 284). The author points out that the apparent equilibrium states observed by Pélabon can be only due to the small value of the reaction-velocity, since he has been able without difficulty to pass these supposed limiting states in his own experiments.

In answer to an objection of Duhem's, he states the quantities of sulphur employed by himself in his experiments on the combination of sulphur and hydrogen, and shows that the amount of sulphuretted hydrogen dissolved by these quantities would, according to Pélabon's own experiments, be very small. Duhem's main criticism appears therefore to be refuted. F. G. D.

673. *Numerical Laws of Chemical Equilibrium.* **O. Boudouard.** (Comptes Rendus, 130. pp. 132–134. Jan. 15, 1900.)—By means of le Chatelier's formula for the equilibrium of gaseous mixtures the author calculates the relative proportions of carbon dioxide and carbon monoxide in the gases resulting from the action of carbon dioxide on carbon at temperatures between 450° and 1050°, and obtains results agreeing well with the experimental values previously found. At 450° carbon dioxide is scarcely acted on by carbon, whilst at 1050° it is almost completely converted into monoxide; between 650° and 700° the gases are present in equal volumes. N. L.

674. *Osmotic Pressure of Concentrated Solutions.* **T. Ewan.** (Zeitschr. Phys. Chem. 31. pp. 22–34, Dec. 22, 1899.)—By means of a reversible cycle the author obtains a general relation connecting the osmotic pressure of a solution with its freezing-point, in which no special assumption is made regarding the equation of state of the solute. In order to calculate the osmotic pressure from this relation it is necessary to know the freezing-point of the solution, the heat of dilution, the temperature-coefficient of the heat of dilution, the change of volume accompanying dilution, and also the heat of fusion, the specific heats in the solid and liquid states, and the freezing-point of the solvent.

The author describes his method of determining the freezing-points. The solution (or solvent) was contained in a glass tube, which was set inside a brass tube closed by a hollow glass stopper filled with a cryohydrate whose equilibrium-temperature was very near the required freezing-point. The brass tube was placed inside a glass vessel containing the same cryohydrate, and this glass vessel was in its turn immersed in a freezing-mixture of ice and salt.

The solute was cane sugar, and the solutions were analysed by drawing off a portion of the solution *in equilibrium with* the separated ice an-

determining its density. By means of his own results and other data the values of $\left(\frac{\partial P}{\partial T}\right)_v$ corresponding to various dilutions are calculated. It is found that these results can be expressed by the formula :—

$$\left(\frac{\partial P}{\partial T}\right)_v = \frac{R}{V - \frac{V - nM_o v_o}{m}}$$

Here R = the gas constant (for hydrogen) = 84820 g. cm.; M_o = molecular weight of water; V = volume of solution containing 342 grms. of sugar and nM_o grms. water; $nM_o v_o$ = increase of volume which would occur if nM_o grms. water were added to the solution without appreciably changing its concentration; m = grms. of water to 1 grm. sugar. Now from the free energy equation (*cf* Nernst, *Theoretische Chemie*) it follows that :—

$$Pv_o = T\frac{\partial}{\partial T}(Pv_o) + J\frac{\partial Q_T}{\partial m}$$

where $\frac{\partial Q_T}{\partial m}$ is the "instantaneous" heat of dilution at dilution m and temperature T. Hence combining both equations :—

$$P = \frac{RT}{V - \frac{V - nM_o v_o}{m}} + \frac{J}{v_o}\frac{\partial Q_T}{\partial m}.$$

In order to completely solve the present problem it would be necessary to be able to express $\frac{\partial Q_T}{\partial M}$ as a function of the concentration. F. G. D.

675. *Freezing-points of very Dilute Solutions.* **M. Wildermann.** (Zeitschr. Phys. Chem. 30. pp. 508–526, Dec. 1, 1899. Compare Roy. Soc., Proc., 1896.) —(1) When the freezing-point is depressed by about 0·02° ice separates in the form of needles or flakes throughout the solution, but if the depression is only a few thousandths, it separates in bands or in a continuous cap on the bulb of the thermometer. (2) The freezing-point of water, freed from ammonia and carbon dioxide by a current of pure air, varies to a noticeable extent owing to the presence in it of a variable amount of dissolved oxygen, and other non-electrolytic matter. (3) Care must be taken that the values of the freezing-point do not vary by more than a few ten-thousandths of a degree when repeated at intervals of 10 or 15 minutes, as otherwise an error is present, due to the distortion of the bulb by change of temperature. (4) The readings of the 1/1000°-thermometer are influenced to the extent of 0·0003° per mm. by variation in the height of the barometer. (5) The thermometer adjusts itself completely to alterations of pressure within two minutes. (6) An opposite effect, of exactly equal magnitude, is produced by the rise of the mercury column in the stem of the thermometer. (7) This effect is present also in the calibration of the thermometer; but, since the change of pressure is proportional to the reading of the thermometer, and the effect is rapidly produced, scale-divisions of uniform length give correct readings, even when the length of the scale is different on different thermometers. (8) One mm. variation in pressure alters the reading of the 1/100°-thermometer to the extent of about 0·00015°. (9) Errors due to inexact calibration of pipettes, &c., are not more marked in very dilute solutions than in more concentrated. The author supposes that his method is accurate within 1, 2, or 3 ten-thousandths of a degree.

The author gives directions for the use of the thermometers, and discusses *their accuracy.* T. M. L.

676. *Cryoscopic Investigations on the Constitution of Acid-amides.* **K. Auwers.** (Zeitschr. Phys. Chem. 30. pp. 529–544, Dec. 1, 1899.)—Unlike the phenols, the thiophenols as a rule show a normal cryoscopic behaviour when dissolved in naphthalene, but abnormal values are obtained where negative groups are present—as, for instance, in thioacetic acid, $CH_3.CO.SH$.

Substitution only has the effect of diminishing the abnormality of a substance when the radicle is attached to the carbon atom adjacent to that which carries the group (OH or NH) responsible for the abnormal behaviour. Thus o-nitroacetanilid differs from acetanilid in that it behaves quite normally, but in o-nitrobenzylacetamide, $NO_2.C_6H_4.CH_2.NHAc$, the nitro-group is without influence, and the substance shows the same abnormal behaviour as benzyl-acetamide; similarly it is shown that the substituted benzaldoximes and benzylalcohols all show the abnormal behaviour of benzaldoxime and benzylalcohol, even when the substituting group is in the ortho-position.

In the acid-amides the group which causes the abnormal behaviour may be either OH or NH, according as the formula $R.C(OH):N.R'$ or $R.CO.NH.R'$ is used; if the hydroxylic formula is correct o-nitrobenzanilid and benz-o-nitranilide should both be abnormal, whilst the keto-imide formula would make o-nitrobenzanilid abnormal and benz-o-nitranilid normal; experiment shows that all the substituted benzanilids behave abnormally, except those in which substitution takes place in the ortho-position in the aniline-group, thus confirming the ordinary keto-imide formula for the amides.

Imido-compounds are not abnormal when they possess a marked basic character; thus diphenylamine, methylaniline, and the imido-ethers behave normally when dissolved in benzene, but urethane gives very high values, and phenylurethane is also abnormal, though to a less degree. T. M. L.

677. *Gibbs' Phase-Rule.* **C. H. Wind.** (Zeitschr. Phys. Chem. 31. pp. 390–397, Dec. 22, 1899.)—The author remarks that the phase-law is generally given as a deduction resulting from a series of thermodynamical equations, but that it ought to be possible to give a simple and yet perfectly general proof of it based on general reasoning. He objects to the proofs given by Nernst and by Bancroft as being not really rigid. In the proof here given by himself the basis of the argument is the *existence* of the entropy function, not any particular analytical expression of the second law. F. G. D.

678. *Solidification of Mixtures of Two Substances.* **H. W. B. Roozeboom.** (Zeitschr. Phys. Chem. 30. pp. 385–412, Dec. 1, 1899.)—The author discusses the phenomena accompanying the solidification of a fused mixture of two substances under the following types:—

A. The mixture solidifies to a continuous series of mixed crystals of the same kind. (1) Solidification-points of all mixtures lie between those of the two constituents. (2) The solidification curve shows a maximum, or (3) a minimum.

B. The mixture solidifies to an interrupted series of mixed crystals of the same kind. (4) The solidification curve shows a transition-point, or (5) a eutectic-point.

C. The mixture solidifies to two kinds of crystals.

The first type represents the behaviour of mixtures of two substances which are completely isomorphous, but the author holds that the solidification curve can only be a straight line when the melting-points of the components are identical, and that this has only been observed experimentally in

the case of optical isomerides, such as d- and l- camphoroxime, the melting-point curve of which is a horizontal straight line. Examples are also quoted from the experimental work of a large number of authors to illustrate the remaining types of mixtures. T. M. L.

679. *Transition-points of Mixed Crystals.* **H. W. B. Roozeboom.** (Zeitschr. Phys. Chem. 30. pp. 413–429, Dec. 1, 1899.)—A theoretical discussion of the transition-points of mixed crystals, classified into eight different types, similar to the discussion of the solidification-points in the preceding Abstract. T. M. L.

680. *Formation and Polymorphous Change of Mixed Crystals of Potassium and Thallium Nitrates.* **C. van Eyk.** (Zeitschr. Phys. Chem. 30. pp. 430–459, Dec. 1, 1899.)—A series of experiments undertaken in order to test the theoretical conclusions of the two preceding papers. Potassium nitrate melts at 339° and thallium nitrate at 206·1°; the solidification curve for mixtures of the two nitrates consists of two parts, the intersection of which corresponds to a eutectic-point, so that the mixture belongs to the fifth type described in Abstract No. 678 (1900). The temperature of the eutectic-point is 182°, and represents the solidification-point of a mixture containing 81·3 per cent. of KNO_3.

In order to determine the relationship between the composition of the melt and that of the crystals, a small quantity of the liquid was allowed to solidify in a special apparatus, in which the crystals could be separated and drained, and the thallium was then estimated by precipitation as thallium iodide. Mixtures containing more than 81·3 per cent. of potassium nitrate deposit crystals, which are richer in potassium nitrate than the liquid from which they separate, whilst mixtures containing less than 81·3 per cent. of KNO_3 deposit crystals richer in $TlNO_3$; since the former are lighter and the latter are heavier than the liquid from which they separate, the composition of the eutectic mixture (81·3 per cent. KNO_3) can be very accurately determined. By extrapolation it is found that the two types of crystals which separate together at the eutectic-point contain respectively 20 and 50 molecules per cent. of KNO_3; their densities should be 5·24 and 4·57, but the mixture is too intimate to allow of the separation of the crystals by any mechanical method.

If the whole of the liquid be allowed to solidify the nature of the phenomena will depend on whether the solid phase adjusts itself to the changing composition of the liquid phase or not; in practice, it appears that the crystals which first separate, and which are no longer in equilibrium with the liquid phase in its altered composition do, to some extent, redissolve, but that the adjustment of the solid phase to the altered conditions is only partial.

Potassium and thallium nitrates both crystallise in the rhombohedral system at high temperatures, but there is a gap in this "α" isomorphous series, since mixed crystals containing between 20 and 50 per cent. of KNO_3 are not formed at 182°. At ordinary temperatures the nitrates form a second "β" isomorphous series of rhombic crystals, but here also, as Fock has shown, there is a gap. The transition-point for potassium nitrate lies between 125 and 128°, and thallium nitrate was found to show a similar transition point at 142·5°. The transition-point of each is lowered by the addition of small quantity of the other nitrate, the lowest value of the transition-point being 138° on the side of the $TlNO_3$, and 108·5° on the side of the KNO_3; a

these changes occur over a definite temperature interval. The conglomerates of crystals, which appear when the composition of the mixture lies outside the miscibility limits of the two substances, show two transition-points; if the series of mixed crystals richer in $TlNO_3$ be described as α (rhombohedral) and β (rhombic) and those richer in KNO_3 as α' and β', then at 133° the α crystals become unstable and break down into a conglomerate of β and α' crystals, which are then the stable forms, and at 108·5° the α' crystals break down similarly into a conglomerate of β and β' crystals.

The miscibility limits are as follows:—

(1) At the eutectic-point, 182°, $\alpha = 20\%$, $\alpha' = 50\%$ KNO_3.
(2) At the upper transition-point, 133°, $\beta = 20\%$, $\alpha' = 69\%$ KNO_3.
(3) At the lower transition-point, 108·5°, $\beta = 35\%$, $\beta' = 84\%$ KNO_3.
(4) At 25°, $\beta = 19\%$, $\beta' = 94\%$ KNO_3.
(5) At 10°, $\beta = 15{\cdot}5\%$, $\beta' = 96{\cdot}5\%$ KNO_3. T. M. L.

681. *Equilibrium in the System, Water-Phenol-Aniline.* **F. A. H. Schreinemakers.** (Zeitschr. Phys. Chem. 29. pp. 577–602, and 30. pp. 460–480, 1899.)—I. The limits of miscibility of water (W), aniline (A), and phenol (P) at different temperatures are shown by the isotherms in the accompanying triangular diagram. Aniline and phenol are completely miscible at all temperatures, but form an additive compound, $C_6H_5OH.C_6H_5NH_2$, (V), which melts at 31°. Water and phenol are completely miscible above 68°, at which temperature the composition of the two layers becomes identical at W = 65 per cent., P = 35 per cent. Water and aniline are completely miscible above 167°. The field in which two liquid phases appear is, in this case, continuous for each temperature, whereas in the system water-alcohol-succinonitrile two areas appear, the isothermals being in the form of two loops.

The addition of sodium chloride (6·47 per cent.) to a mixture of water and phenol, *raises* the miscibility limit from 68° to 143°, but the addition of alcohol (11·18 per cent.), which dissolves chiefly in the phenol and not in the watery layer, *lowers* the miscibility limit to 54·5°.

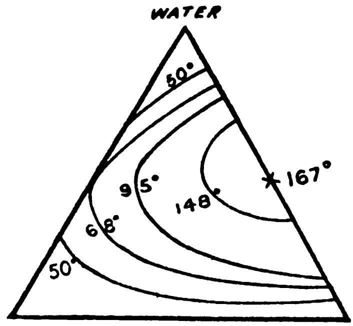
II. On cooling mixtures of water with aniline or phenol three cases are possible according as (1) each deposits ice, (2) each deposits solid aniline or phenol, (3) one deposits ice and the other deposits aniline or phenol. It is found by experiment that mixtures of water and phenol deposit solid phenol, but mixtures of water and aniline deposit ice; the system therefore belongs to the third type, but is complicated by the fact that V may also separate as a solid phase.

Ice and aniline can exist together as two solid phases in contact with a single liquid phase at temperatures between −12° (eutectic-point for W and A, with no phenol in the liquid phase) to −17°. Ice and phenol can exist as solid phases in contact with a single liquid phase under two sets of conditions: if the liquid phase consists chiefly of phenol the maximum temperature is −1·1°, whilst if the liquid phase consists chiefly of water the maximum temperature is −0·9°, the eutectic-point for W and P. Similarly ice and V can exist together as solid phases up to −0·9° in a mixture consisting chiefly of phenol, and up to −0·5° in a mixture consisting chiefly of aniline; in contrast to these limiting temperatures a genuine maximum temperature occurs for this system when P and A are present in molecular proportions; this is the eutectic-point for W and V and occurs at −0·8°, falling to a limiting temperature of −0·5° or −0·9° when aniline or phenol is added in excess of the proportions in

which they combine to form V. Aniline and phenol as solid phases in contact with a single liquid phase have not been observed, but phenol and V, or aniline and V, may separate together at temperatures up to the eutectic-points, + 15° and — 11·7° respectively.

Two liquid phases can occur in contact with solid phenol from 1·5° (no aniline) to — 1·1° and in contact with ice from — 1·1° to — 0·9°, but solid aniline has never been observed experimentally in contact with two liquid phases. The maximum temperature at which the solid V can occur in contact with two liquid phases is 17·8° when aniline and phenol are in molecular proportions, falling to — 0·9° and 0·5° in presence of an excess of phenol or aniline respectively.

In mixtures of V with water there will be a definite transition-temperature



(Uebergangstemperatur) at which alone the solid is in equilibrium with two liquid phases (1) if the compound V passes into solution unchanged, or (2) if it breaks up in solution, but the aniline and phenol are still in molecular proportions in each layer ; in the latter case the effect on the transition-point of adding an excess of phenol or aniline will be represented by a continuous curve, since these are already present in the solution, but in the former case by two intersecting curves. If, however, the aniline and phenol produced by the dissociation of V are distributed unequally between the two liquid layers the transition-point will be broadened into a *transition-interval;* the solubility curve for the solid V in water indicates the presence of a narrow transition-interval from 16·9 to 17·2°. T. M. L.

682. *Equilibria in the System, Water-Ethyl Ether-Succinonitrile.* **F. A. H. Schreinemakers.** (Archives Néerlandaises, 8. pp. 1–78, 1899.)—The author, in continuation of his researches on phase-equilibria in which several liquid phases may coexist, describes in this paper a system in which *three* coexisting liquid phases make their appearance. The paper contains the experimental results, and a discussion of them by means of triangular diagrams and other graphical methods of representation. A theoretical treatment of the case of three coexistent liquid phases is postponed for a later paper. (See also 1898, Abstract No. 1261.) F. G. D

683. *Dilution Law.* **W. D. Bancroft.** (Zeitschr. Phys. Chem. 8 pp. 188–196, Dec. 22, 1899.)—The formulæ put forward by Ostwa (*Zeitschr. Phys. Chem.* 36, 1890) and by van't Hoff (*Ibid.* 18. 300, 1895)

express the effect of dilution on the dissociation of weak and of strong electrolytes respectively are special cases of the formula $K = C_i^n / C_s$ (Storch, Zeitschr. Phys. Chem., 19. 13, 1896), where C_i and C_s represent the concentration of the ions of a binary electrolyte and of the undissociated salt respectively. Ostwald's formula ($n = 2$) gives good values in the case of weak acids and bases, whilst van't Hoff's formula ($n = 1{\cdot}5$) gives good values with "strong" electrolytes; it is now suggested that n should be determined empirically by plotting a curve with the values of log C_s as abscissæ and log C_i as ordinates; the curves are all straight lines, but deviate at high concentration, and in the case of concentrated solutions of KOH, HCl and LiCl maximum points occur; the inclination of the straight-line curve gives the value of n. Tables are given for 10 salts for which n varies from 1·86 (potassium chloride) to 1·55 (silver nitrate), and it is shown that the values of 100α (the percentage dissociation) calculated rom the formula agree closely with the observed values up to a concentration approaching $C = 1$. It is suggested that the deviations in more concentrated solutions may be due in part to a variation of the migration velocity of the ions with the concentration, but may also be due to the conductivity ceasing to be a true measure of the degree of dissociation.

T. M. L.

684. *New Inorganic Ionising Solvent.* **P. Walden.** (Ber., 32. pp. 2862–2871, Nov., 1899.)—Liquid sulphur dioxide dissolves a number of inorganic salts, as well as hydrocarbons, alcohols, organic acids, esters and bases. Many of the solutions show characteristic colours, and double decompositions and colour-reactions take place as readily as in aqueous solutions. Conductivity measurements are given for solutions, in liquid sulphur dioxide at 0°, of potassium, sodium, ammonium and rubidium iodides, potassium bromide, potassium and ammonium thiocyanates, trimethylsulphine iodide, tetramethyl and tetraethylammonium iodides; in the case of the last three substances the values for the conductivity were considerably greater that those for similar solutions in water at 0°. Molecular weight determinations made by Landsberger and Walker's method showed that potassium, sodium, rubidium and ammonium iodides are polymerised in solution in sulphur dioxide, but potassium thiocyanate, trimethylsulphine iodide, tetramethyl- and tetraethylammonium iodides appear to be dissociated to a very considerable extent. The molecular elevation of the boiling-point was calculated from the boiling-point and latent heat of fusion to be 15·02, whilst an experimental determination with non-electrolytic solutions of naphthalene, toluene, and acetanilid gave $E = 15{\cdot}0$. T. M. L.

685. *Electrolytic Conductivity of Non-Aqueous Solutions.* **A. T. Lincoln.** (Journ. Phys. Chem. 3. pp. 457–494, 1899. From the Transactions of the Wisconsin Academy of Sciences, Arts, and Letters, vol. 12. pp. 395–458.)—This is practically a continuation of the paper referred to in Abstract No. 781 (1899). Qualitative and quantitative measurements were made with a large number of organic solvents. A great part of the paper is filled with a discussion of the work of other observers, and should prove useful as a bibliographical review. W. R. C.

686. *Ionisation of Salts in Methyl and Ethyl Alcohols.* **H. C. Jones.** (Zeitschr. Phys. Chem. 31. pp. 114–141, Dec. 22, 1899.)—The method employed consists in determining the rise of boiling-point. The author uses an apparatus for which he claims that *it reduces* radiation errors to a

minimum, prevents the cold condensed solvent from coming into contact with the thermometer, and renders a vapour-mantle unnecessary. The salts investigated in methyl alcohol are the iodides and bromides of potassium, sodium and ammonium, potassium and sodium acetates and calcium nitrate. For the halides the calculated dissociations run from 47 to 64 per cent. For the acetates the value is about 88 per cent., while for calcium nitrate it is about 14 per cent. The salts investigated in ethyl alcohol are the iodides of potassium and sodium, the bromides of sodium and ammonium, potassium and sodium acetates, and calcium nitrate. The dissociations are here much smaller than in the case of methyl alcohol. (See also 1898, Abstract No. 1878.)

F. G. D.

687. *Influence of Substances Containing a Common Ion on the E.M.F of Concentration Cells and on the Velocity of Diffusion.* **R. Abegg** and **E. Bose.** (Zeitschr. Phys. Chem. 30. pp. 545-555, Dec. 1, 1899. From the Jahresbericht der Schlesischen Gesellschaft für Vaterländische Kultur.)—Employing Nernst's theory it is shown that the E.M.F. of a liquid cell containing two solutions of different concentrations of an electrolyte KA will be diminished by the addition of an electrolyte K'A in equal concentration on both sides.

Proceeding to electrolytic diffusion the authors show that an electrolyte will diffuse with a velocity corresponding to the mobility of its anion or its kation, according as the solution (through addition of another electrolyte) contains a great excess of the kation or anion respectively. On this result they base a hypothetical explanation of the influence exerted by neutral salts in increasing the catalytic action of hydrogen ions, as observed by Arrhenius in the inversion of sugar.

F. G. D.

688. *E.M.F. of Cells and Thermo-Chemical Data.* **D. Tommasi.** (Elect. Rev. 45. pp. 1063–1064, Dec. 29, 1899.)—The author enunciates the law that when one metal replaces another in a saline solution the heat evolved for a given metal is the same (called the thermic constant) whatever the nature of the acid radicle. Hence the E.M.F. of a cell of the Daniell type is independent of the electrolytes. Examples are given of the calculation of E.M.F. of two-fluid cells. In the case of one-fluid cells the E.M.F. is given by the difference of the thermic constants of the metal dissolved and of the hydrogen evolved.

W. R. C.

689. *E.M.F. and Chemical Equilibrium.* **V. Rothmund.** (Zeitschr. Phys. Chem. 31. pp. 69–78, Dec. 22, 1899.)—Van't Hoff's well-known equation—

$$E = RT \log k$$

(where k is the reaction constant) is applicable in many cases where the reaction is not directly an electrochemical one. Thus the reversible dissociation of a metallic oxide, say—

$$HgO \rightleftarrows Hg + O$$

can be brought under it by measuring the E.M.F of the cell—

$$Pt : O_2 : \text{normal } NaOH : HgO : Hg.$$

By means of a cyclic process of thermodynamics the author shows that—

$$E = \frac{RT}{4f} \log p$$

where p is the dissociation pressure, and f = quantity of electricity associ

with 1 gram-equivalent. For mercuric oxide this gives $p = 10^{-10.96}$ atmos. Accordingly mercury should oxidise in air at ordinary temperature: that it does not in practice may be set down to excessive slowness of reaction, or to a "false equilibrium"; the numerical result does not, however, agree with those of Pélabon for high temperatures. Other cases are considered similarly, but without numerical results. R. A. L.

690. *Electrolytic Reduction of Potassium Chlorate.* **A. L. Voege.** (Journ. Phys. Chem. 3. pp. 577–601, Dec., 1899.)—In order to obtain data which may serve as a basis for a theory of electrolytic reduction, an exhaustive quantitative study has been made of the reduction of potassium chlorate, this salt being chosen on account of the ease with which it and its reduction products can be analytically determined, and also because the total yield varies much with changing conditions. The author draws the following conclusions from the experimental results, full details of which are given in the paper. (1) The reduction is greater in acid than in alkaline solutions. (2) The amount of reduction varies with the metal used for the electrodes, zinc being more efficient than cadmium, and the latter more so than platinum. (3) With zinc and platinum the reduction increases greatly with decreasing current density, whilst this is not observed with cadmium. (4) The reduction yield is greatly affected by the physical structure of zinc electrodes, large crystals being associated with a higher efficiency. (5) An increase of temperature greatly facilitates reduction. (6) The reduction depends largely on the strength of the sulphuric acid used, the maximum efficiency being obtained with about 1·5 normal strength. (7) Decreasing the current strength increases reduction, but this result is possibly due to the change in voltage occurring. (8) No electrolytic reduction occurs at the anode in zinc, cadmium, and platinum cells, all chloride found there being due to the action of the acid and to diffusion from the kathode cell. (9) Potassium zincate is formed at the kathode by the secondary reaction of potassium hydroxide, electrolytically formed, with the zinc, and the hydrogen resulting from this reaction is used in reduction, making it possible to obtain an electrolytic efficiency of more than 100 per cent. (10) Copper is only slightly attacked by sulphuric acid alone, but is readily dissolved in the presence of potassium chlorate, and an almost quantitative yield of potassium chloride is obtained. (11) This reduction by copper without electrolysis is about four times that by zinc for equivalent quantities dissolved, although zinc dissolves much more slowly than copper. (12) With copper electrodes the electrolytic reduction is probably less than with zinc electrodes, but this is difficult to establish conclusively because of the great amount of reduction due to purely chemical causes when copper is employed. N. L.

691. *Electrolysis of Potassium Chloride.* **A. Brochet.** (Comptes Rendus, 130. pp. 134–137, Jan. 15, 1900.)—A series of experiments on the lines of those described by Foerster (see 1899, Abstract No. 1946) was made, reduction being entirely prevented by the addition of potassium bichromate, as recommended by Müller (see 1899, Abstract No. 1408). In one of the experiments, the results of which are represented by curves, a solution containing 20 per cent. of potassium chloride, 0·1 per cent. of potassium bichromate, and 0·2 per cent. of caustic potash was electrolysed at 16°–20° between platiniridium electrodes, using a current density of 0·045 ampere per square centimetre at 3·4–3·85 volts. In the first $1\frac{1}{4}$ hours the total current efficiency fell from 98

to 90 per cent., and in the same time the amount of hypochlorite attained its constant value, equivalent to about 15 grammes of chlorine per litre. The proportion of chlorate formed increases very slowly during the time that hypochlorite is produced, but afterwards increases rapidly and uniformly until it becomes constant. The electrolysis of water, very slight at first, gradually increases and becomes constant at the end of three hours. Without alkali the current yield is still higher and more hypochlorite is formed, whilst if more alkali is added the yield, and the production of hypochlorite, decrease. The yield of potassium chlorate is over 70 per cent., whereas without the addition of chromate not more than 35 per cent. is obtained. N. L.

692. *Electro-deposition of Zinc.* **S. Cowper-Coles.** (Electrician, 44. p. 434, Jan. 19, 1900.)—The experiments described by the author were undertaken in order to determine the adhesiveness of zinc to steel, when deposited under varying conditions as regards preparation of the steel plates, acidity of the electrolyte, and current strength. It was found that perfect adhesion was only secured when the current was reversed for a few moments before commencing the deposition. In other cases the deposit was non-adhesive, a result ascribed by the author to the slight film of oxide which covered the steel. Neutral solutions were found to yield the most regular and even deposits. J. B. C. K.

693. *Merits of Finely and Coarsely Powdered Materials in Manufacture of Calcium Carbide.* **B. Carlson.** (Zeitschr. Elektrochem. 6. pp. 324–328, Dec. 7, 1899.)—The author fully discusses the respective merits of coarsely and finely powdered raw materials in the manufacture of calcium carbide, and expresses his opinion as to the advantage of a coarse mixture. The heat necessary for obtaining the carbide is partly utilised in heating and melting the raw materials, *i.e.*, carbon and lime. Neither the specific nor the melting heat of these two bodies is affected by the size of the grains employed. A number of proofs in favour of a coarse mixture are given, such as the solubility of the raw materials in the already formed carbide, and the greater ease with which the gases formed can find their exit without giving rise to explosive eruptions, as in the case of a dense mixture, and the accompanying throwing up of fine dust, &c. Another important point seems to consist in the better utilisation of the heat of the gases generated in their upward passage and also the prevention of bridging over of the molten particles.

The theoretical quantity of lime and coke together for the production of 1,000 kilos of carbide equals 1,440 kilos. Actual trials by the Deutsche Gold and Silber Scheideaustalt in Frankfort have shown that 1,590 kilos are required in practice with the coarser mixture there employed. In the case of fine material 8,000 kilos and upwards are required. The process used at the above works is the one introduced by J. Pfleger for employing coarse mixtures, and has some novel features which the author promises to discuss in a future communication. O. J. S.

694. *Cost of Calcium Carbide.* **H. Allen.** (Elect. Rev. 46. pp. 7–8, Jan. 5, 1900.)—The author bases the estimates given in these notes upon theoretical data, and upon the lowest realised cost for electrical energy when derived from water-power, namely, 0·181d. per B.T.U. Using these figures, he estimates that one ton of carbide should cost £9 5s. 5d. The details of his estimate are as follows :—

	£	s.	d.
2·143 tons Limestone at 10s. (crushed)	1	1	5
0·80 ton Coke at 20s. (crushed)	0	16	0
4874 B.T.U. at 0·131d.	2	11	8
Electrode Carbons	1	0	0
Labour, Oil, Waste, Interest and Maintenance Charges	3	16	4
	£9	5	5

The author states that this result can be improved upon by use of blast-furnace gases for power generation by the Thwaite-Gardner or other system, and reference is made to the installation of the former for carbide production at an ironworks in Westphalia. J. B. C. K.

695. *Ducasse Electric Furnace.* (Ind. Électrochim. 3. pp. 116–117, Nov., 1899. From the *Ingénieur français* through *Electro-chimie*, 1899, p. 174.)—The furnace is circular in plan with a movable hearth, the whole of which acts as the negative electrode. A tap-hole is provided to run off liquid smelting-products, and in the upper portion of the furnace is a side flue, provided with a sight-hole and cleansing door; through this flue the heated furnace gases are carried to a chamber in which the furnace-charge is pre-heated. The furnace is surmounted with a domed cover fitted with an eye-bolt by which it may be raised from its position, and perforated with charging doors, and with four apertures, through each of which passes one of four carbon rods forming the positive electrodes. These electrodes are supported from above in such a way that their position may be regulated automatically or at will. By means of a motor working on a shunt from the main circuit, a rotary current-distributor causes the main current to pass through each of the electrodes in succession 3,000 times a minute, contact with any one carbon not being broken until that with the next has been made, so that sparking is avoided. There is in this way produced in the hearth of the furnace an arc which practically rotates at 3,000 revolutions per minute. W. G. M.

REFERENCES.

696. *Electromotive Behaviour of Chromium.* **W. Hittorf.** (Zeitschr. Phys. Chem. 30. pp. 482–507, Dec. 1, 1899.)—Details of paper previously noticed. (See 1899, Abstract No. 1744.) N. L.

697. *Electro-Galvanising, Notes on.* **S. Cowper-Coles.** (Indus. and Iron, 28. pp. 69–70, Feb. 2, 1900.)—A paper similar to those referred to in Abstracts Nos. 490 (1899), 286 and 548 (1900). J. B. C. K.

STEAM PLANT, GAS AND OIL ENGINES.

698. *Receiver Drop in Multiple Expansion Engines.* **R. L. Weighton.** (Mech. Eng. 5. pp. 124–127, Jan. 27, 1900. Abstract of paper read before the North-East Coast Institution of Engineers and Shipbuilders, at Newcastle-upon-Tyne, Jan. 19.)—The author gives results of trials to determine the most economical point of cut-off in the larger cylinders of multiple expansion engines. The deductions from the results of the trials are :—

$$(1) \qquad \frac{\text{Maximum-economy cut-off}}{\text{Stroke}} = \frac{R + 6{\cdot}6}{6{\cdot}6\,R}$$

where R = the ratio between the capacities of the given cylinder and the preceding cylinder.

(2) If maximum economy at all powers is to be preserved, the cut-off in larger cylinders, once fixed, should never be altered, whatever may be the cut-off in the H.P. cylinder, or the steam pressure.

(3) The cut-off of maximum power coincides with the cut-off of maximum economy in L.P. cylinder of triples, and the second intermediate and L.P. cylinders of quadruples. The maximum-power cut off is considerably later than that of maximum economy in second cylinder of triples and quadruples. In compounds the maximum-power cut-off in the L.P. cylinder is only slightly later than that of maximum economy.

(4) When R is from 2 to 2·5 the cut-off in larger cylinders may be varied considerably without an appreciable fall in economy, but where R is large, deviation entails a fall in economy.

(5) With given efficiency in receiver drop, smallness of cylinder ratio is conducive to smoothness of working, uniformity of turning, durability, handiness in starting and reversing, and compactness of design. J. T. R.

699. *Friction Tests of a Locomotive Slide Valve.* **F. C. Wagner.** (Mech. Eng. 4. pp. 857–858, Dec. 9, 1899. Paper read before the American Society of Mechanical Engineers, Dec., 1899.)—During some recent locomotive tests made at the Rise Polytechnic Institute by Butler and Crebs it was found desirable to operate one of the valves by an electric motor. It occurred to the writer that some useful data upon the friction of a locomotive slide valve might easily be obtained. The power used to drive the valve was obtained by measuring that delivered to the motor, and making allowances for the efficiency of the motor and the friction of the transmitting mechanism. Two tests were made, and the results are given in tabular form ; in one trial the coefficient of friction was 0·050, in the other trial 0·036. A. S.

700. *Friction of Steam Packings.* **C. H. Benjamin.** (Mech. Eng. 4. pp 888–889, Dec. 9, 1899. Paper read before the American Society of Mechanic Engineers, Dec., 1899.)—The experiments described in this paper were mad at the Case School by senior students under the direction of the writer. Th *apparatus* consists of a cast-iron cylinder 6 × 18 inches inside, fitted at eac

end with a cover and stuffing-box suitable for a 2-inch rod. The rod was given a reciprocating motion by means of a slotted cross-head and crank, a pulley on the crank was connected by a belt with a transmission dynamometer, steam was admitted to the cylinder, and the condensed water drained off from time to time. The travel of the rod was 4·25 inches, and the usual speed about 200 revolutions per minute, giving a piston speed of 140 feet per minute. Seventeen different varieties of packing were tested, none being metallic packings strictly so called. The apparatus was first tested empty to determine the friction, the packing was then inserted and adjusted, and the steam turned on. The very least pressure which would prevent leakage was used on the gland nuts. The packing was then tested under steam pressures, each run lasting from 15 to 40 minutes. The results are given in a table, and the effects of varying steam pressure and of tightening the gland nuts are discussed.

The following general conclusions are drawn: (1) the softer rubber and graphite packings, which are self-adjusting and self-lubricating, consume less power than the harder varieties. (2) Oiling the rod reduces the friction with any packing. (3) There is almost no limit to the loss caused by the injudicious use of the spanner. (4) The loss of power varies almost directly with the steam pressure in the harder varieties of packing, but is nearly constant with the softer kinds. A. S.

701. *Packing Ring for Piston Valves.* (Mech. Eng. 4. p. 752, Nov. 18, 1899.) —A description of a packing ring for piston valves for a heavy freight locomotive built for the Illinois Central Railroad by the Brooks Locomotive Works. The packing ring is made in one solid piece, and turned up of larger diameter than the bore of the bushing. A saw-cut is made on the bevel across the ring and a shim of the required thickness is inserted. The ends are then clamped together by a bolt, lugs for the purpose being provided on the inside of the ring, and accurately turned to the proper size. The design seems to have the advantage of a plain plug valve and an additional one, in that the valve may at any time be made tight with comparatively little expense. A. S.

702. *Water-tube Boilers in the U.S. Navy.* **G. W. Melville.** (Mech. Eng. 4. pp. 897–899, Dec. 16, 1899. Abstract of paper read before the Society of Naval Architects and Marine Engineers, New York, Nov., 1899.)—The adoption of water-tube boilers in all future vessels of the U.S. Navy is a natural step in the advance towards a perfect naval fighting machine. The engineer-in-chief of that navy considers that the design of these boilers is wrong in principle on account of the pressure being inside, instead of on the outside, of the tubes, these being the weakest part of the boilers; also on account of the smaller quantity of water in the boiler, the difficulty of observing a leak, and the decreased value of the heating surface. Nevertheless these boilers are tactical necessities for warships. They are considerably lighter than boilers of the old type, and in consequence the ship having them will be smaller and handier—will have somewhat less draught, and will cost less. The draught of water is the limiting condition in size of warships, so that for a maximum of fighting efficiency water-tube boilers must be used. Any saving of weight or space consistent with efficiency is of great importance in war vessels.

All torpedo boats and destroyers in the American navy since the Cushing have been equipped with water-tube boilers, which have proved to be quite

as reliable as the light engines used in these boats, and by making the attainment of higher speeds possible have added to their efficiency and security.

The water-tube boilers in the *Monterey*, the *Nashville*, the *Marietta*, the *Annapolis*, and the *Chicago*, of different designs, have come successfully through a number of trials—the *Monterey* having made a voyage of about 8,000 knots, largely under forced combustion, and whenever possible with all boilers in use, and the *Marietta* having made a trip round South America, with marked success in the performance of these boilers.

The re-tubing of these boilers has been accomplished on board by the engineering staff of the vessel, without the necessity of laying up the ship at a navy yard, and the parts of new boilers have been assembled and erected in position without disturbing the decks. In the case of vessels having protective decks, the latter is a result of enormous importance, and one impossible with cylindrical boilers.

Particular attention must be given to the feed arrangements with water-tube boilers—the feed pumps must be ample and the regulation easy. The heating surface, which was at first 3 square feet per H.P., as against 2 square feet, necessary with cylindrical boilers, is now 2·4 square feet. The ratio of heating to grate surface is kept up to 40, the grates being larger than those of cylindrical boilers. The increased grate surface obtained with water-tube boilers is an improvement, giving power of sustained sea speed. No trouble has been experienced from salt water or grease in these boilers, but in the short naval war with Spain the U.S. war vessels suffered severely from dropped furnaces in cylindrical boilers. With regard to the accidents and failures reported against water-tube boilers, the author remarks that we hear of all the failures but the successes are never mentioned. He considers that the experience of the last ten years or more in the U.S. and other navies proves that water-tube boilers, when proper precautions are used, can be successfully adopted for the steam-generating plant of ocean-going vessels. A number of warships are being fitted with water-tube boilers. The paper concludes with a summary of the advantages and disadvantages of these boilers which have been discussed. F. J. R.

703. *Accidents to Water-tube Boilers and their Remedies.* **A. Ravier.** (Écl. Électr. 21. pp. 427–429, Dec. 16, 1899. Paper read before the Assoc. Française, at Boulogne.)—The causes of accidents to water-tube boilers have been classified, according to the following table, from statistics collected (in France) for the years 1890–1897. In this table E indicates that the cause was exclusive, and C that it was combined with some other cause.

	E	C
I. Splitting of the tubes.	E	C
1. From formation of scale in the tubes	8	9
2. „ abnormal fall of the water-level	12	1
3. „ worn-out tubes	4	2
4. „ defective manufacture	3	3
5. „ muddy deposits due to bad circulation	5	1
6. „ forcing the boiler	2	4
Total of accidents from known causes	34	20[1]
7. „ unknown causes	8	
II. Other accidents	11	

[1] Ten of these with rupture of the tubes.

Out of 78 accidents, 52 were due to rupture of the tubes, and in the case of 48 of these the exact positions of the tubes in the boilers were as follows:—

Tubes in the bottom rows	17
„ second and third rows from the botttom...	6
„ intermediate rows	18
„ top rows	7
	48

To prevent scale, the only sure method is to have pure water. Otherwise an active circulation must be maintained in the tubes immediately over the fire (which tubes should not be less than 2 inches in diameter); the feed should be delivered in the steam space; all grease should be separated from the condensed steam, and the boiler should be frequently cleaned.

The boiler may be emptied for cleaning either when hot and under steam pressure or when nearly cold. The first method is the more rapid, but frequently causes hard deposits which must be removed by hammer and chisel at the risk of damage to the boiler. The second, though slower, gives rise to muddy deposits which are easily washed out, and therefore it is recommended.

Attentive supervision is the remedy for lowering of the water-level, and the wear of the tubes can be greatly prevented by having them made of nickel steel, containing 25 per cent. of nickel.

In order to confine the effects of ruptured tubes to the smallest possible limits, an automatic tube stopper has been designed by A. Janet for horizontal tubes, which remains at an angle permitting the proper action of circulation in the boiler as long as the currents are flowing in the normal directions, but is quickly forced up into the mouth of the tube when there is a rush of water towards a leak. The pressure in the boiler then holds the stopper in position, and the escape of water and steam is prevented. F. J. R.

704. *Influence of Velocity on Evaporation in Tubes.* **G. Halliday.** (Engineer, 88. p. 658, Dec. 29, 1899. Paper read before the Institute of Marine Engineers.) This is the author's second paper on the heat-absorbing power of water in motion. In his first one (Engineer, 87. p. 478. See 1900, Abstract No. 88), he showed, generally, that up to a certain point, when the source of heat is kept constant, and the difference of temperature between the outflowing hot and the inflowing cold water is about 150° F., the number of thermal units which the water absorbs per minute increases steadily with the speed of flow. This effect is not greatly altered even when the water is heated up to boiling-point, but the rate of absorption is less at that point than at 10° below it. With the apparatus then used, in which superheated steam was caused to heat the water flowing through a spiral glass tube immersed in the steam, there seemed to be a critical point in the velocity beyond which the thermal absorption fell away, sometimes very rapidly. That, however, was due to the heating powers of the apparatus being too limited to cope with the requirements of the water at the higher velocities employed.

In the present paper the author records experiments made with modified apparatus to test the rate of heat transmission with water which is freely giving off steam and is also made to flow through the apparatus at increasing velocities. The former experiments stopped at the boiling-point, so that the effect of a mixture of steam and water *was not* present in them. In this new

series the water, previously heated to boiling-point in a tank, is made to flow upwards through a vertical copper tube heated by a Fletcher gas burner, the mixture of steam and water passing into a separator, from which the water goes to a measuring flask and the steam through a condenser to a graduated measure. The velocity of the water flowing through the heated tube, and the quantity of water evaporated, are expressed in cubic centimetres per 4 minutes—each experiment having been continued for that period. With a moderate flame at the Fletcher burner, kept constant, and varying rates of flow of water, the following are some results :—

Velocity of Water.	Evaporation.
54½ c.c. per 4 minutes	24½
93 " "	23
122 " "	22
378 " "	18
575 " "	15
664 " "	14
762 " "	12

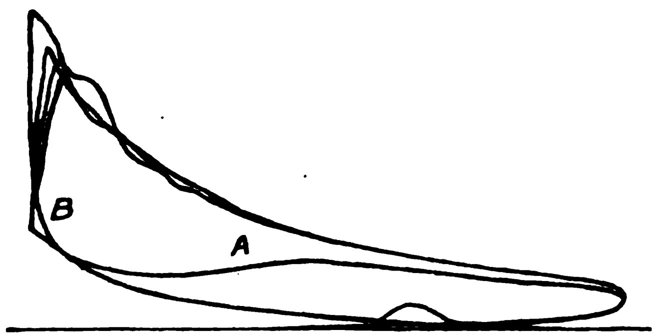
The character of the curves formed by plotting the results in various instances is practically the same, a larger amount of heat merely forming a curve at a higher level. The author observes that (with the small tube used in these experiments), a velocity which gives an evaporation about equal to the quantity not evaporated seems to give the best result.

The author concludes that whilst the quantity of steam evaporated depends on the quantity of heat supplied to the tube, and on the velocity of the water through the tube, yet the greater the speed of the water through the tubes of a water-tube boiler the less will be the evaporation. F. J. R.

705. *Corrosion and Cracks in Locomotive Boilers.* **Desgeans.** (Mech. Eng. 4. pp. 731–735, Nov. 18, 1899. From the Revue Générale des Chemins de Fer ; also the Railroad Gazette.)—The author gives a summarised statement of various defects, such as pitting, grooving and cracks, which are found in locomotive boilers at work, and lead to failure of the boiler or necessitate repairs. The defects are ascribed either to chemical or to mechanical action, or to a combination of both, without entering into any elaboration of the course of such action, except to a small extent in the case of some of the mechanical stresses. Some practical observations on points to be observed in construction and working conclude the paper. F. J. R.

706. *Gas Engines.* **J. Dunlop.** (Mech. Eng. 4. pp. 739–742, Nov. 18, and pp. 766–768, Nov. 25, 1899.)—This paper, read before the Owens College Engineering Society on November 14, 1899, gives the results of an investigation of the troubles experienced with a large gas engine of the high-speed single-acting type, working on the common four-stroke, or "Beau de Rochas," cycle. The usual positions of the crank are shown when the valves are timed to open and close ; also the valve setting of the Crossley scavenging engine, by which it was attempted to utilise the wave action of the exhaust for clearing the burnt products out of the cylinder. Here the air and exhaust valves were open together during the latter part of the exhaust stroke, an the early part of the suction stroke until the exhaust valve was closed lat than usual. The economy effected was found to be almost entirely due an increase in the compression pressure of the engine, and not to t

"scavenging." A Crossley scavenging engine cylinder 18½ inches in diameter by 24 inches stroke was required to develop at 200 revolutions per minute a maximum of 102 B.H.P. for two hours on Dowson gas. To do this it was necessary to maintain, during every possible power stroke, a mean pressure of 75 lbs. per square inch. The engine had only been running a few minutes on trial when explosions in the air pipe began to take place alternately with bumping noises in the cylinder. Indicator diagrams, as shown in the figure, were taken to locate these troubles. The small loop above the atmospheric line is the indication of an explosion in the air pipe during the suction stroke. Consequently during the next power stroke A, the charge of burnt gases only smoulders instead of burning quickly. Light spring diagrams show that the explosions in the air pipe took place at all parts of the suction stroke, and that, owing to the exhaust valve being open during part of the suction stroke, a portion of the hot smouldering exhaust products was drawn into the cylinder. This would also account for pre-ignition, indicated at B, which produces the knocking in the cylinder. In the case of an engine having an ignition timing



valve, this pre-ignition is mostly caused by overheated metal in the cylinder igniting the charge of air and gas, under compression. After the engine had been running twenty minutes, explosions in the air pipe and pre-ignition became almost continuous, and, with the ordinary ignition apparatus out of action, continued for a time to ignite the charges automatically. Although the load was eased the engine pulled up at the end of about half an hour, when the exhaust valve was seen to be a dull red heat, and small pieces of wood laid on the top of the valve took fire immediately. This was remedied by making the exhaust valve hollow for cold-air circulation in the interior of the valve. The writer's contention is that in this scavenging engine the valve-setting was the cause of nearly all the trouble.

When a run was made with the normal valve-setting, the engine acted quite satisfactorily. The mean pressure throughout the stroke was 85 lbs. per square inch with coal gas. A simple and reliable scavenging arrangement, like that in the Premier gas engine, is desirable, especially for engines using Dowson or similar fuel gas. W. R.

707. *Standard Automatic Gas Engine.* (Amer. Electn. 11. pp. 578–579, Dec., 1899.)—The novel feature of the Raymond horizontal gas engine is the valve gear. The one valve, for both admission and exhaust, is a hollow cylinder of cast iron, chilled and ground. As it rotates in the valve chest a port connects the interior of the valve—which is open to the cylinder—

alternately with the admission and exhaust chambers. Ignition is electrical by wiping spark between wide tool-steel electrodes, and the moving contact simply rotates with the valve. Governing is by varying the quantity of the charge, which is throttled by one plain balanced butterfly valve. The proportions of the mixture are determined by valves in the air and gas pipes. Small engines are of the ordinary single-acting form on the Beau de Rochas, or four-stroke cycle. Sizes of 50 H.P. and upward have two tandem single-acting cylinders, with the compression stroke in one following the expansion stroke in the other, giving one impulse every revolution. One long piston-rod runs through the ends of both cylinders, with non-inflammable packing, and is made hollow for the circulation of cooling water.

The large engine has two double-acting cylinders in tandem on one piston-rod with outside cross-head of steam engine construction (like the tandem Griffin double-acting engines at Belfast electric lighting station). The piston-rod is made of nickel steel, drawn with the hole for cooling water, which also passes through the inside of the pistons. One horizontal shaft turns the four hollow cylinder valves for the four ends of the engine cylinders. The engine is started by igniting a charge of very slowly burning powder, also by compressed air or steam supply. This engine is rated at 200 H.P. on the basis of a mean effective pressure of 82 lbs. per square inch, although higher pressures may be obtained, and the engine is guaranteed to develop 300 B.H.P. on 3,000 cubic feet of natural gas per hour, giving 990 B.Th.U. per cubic foot. Two pairs of such tandem engines coupled two together with cranks at 90°, with 4 impulses per revolution, are about to be direct coupled to a three-phase 60-cycle alternator mounted between the cranks. These alternators will be run in parallel, and with rotary converters. W. R.

708. *Gas-Engine Guarantees.* **W. T. Magruder.** (Indus. and Iron, 27. pp. 411–412, Dec. 22, 1899. Abstract of paper presented at the first annual meeting of the National Association of Gas and Gasoline Engine Manufacturers of the United States.)—*Power.*—Some gas engine catalogues fail to distinguish between nominal, indicated, and actual horse-powers. The variation in indicator diagrams, from a gas engine having either a throttling or hit-and-miss governor and a load which varies, prevents greater accuracy than 90 to 95 per cent. in the measurement of the indicated H.P. The continuous indicator is not yet a practical success.

The friction of the engine may use up 10 to 35 per cent. of the work done on the piston. The chief value of the ordinary gas-engine indicator is to show faulty setting of valves, excessive back pressure of exhaust, and obstruction in gas and air inlets. Engines should be sold by the actual power delivered at the belt pulley or crank-shaft, which can be easily measured by a brake.

The accurate *regulation of speed* of gas engines is necessitated by the effects on electric lamps, and the fluctuation is reduced by the kinetic energy of heavy fly-wheels. Guarantees are given in catalogues of gas-engine makers of the variation of speed being only 1 and 1½ per cent., while one claims to run his engine at "an absolutely uniform speed, which may be varied instantly from 50 to 600 revolutions per minute;" but the writer has never seen any steam engine which regulated as badly as some gas engines.

It is essential in making guarantees as to *cost of running* not only to know the cost per cubic foot of gas or per gallon of oil, but also the calorific value of that fuel per cubic foot, per lb. or per gallon, at standard temperature and pressure, knowing the specific gravity, as well as other physical properties o *the fuel.*

Consumption of fuel will vary with the calorific value, and the best proportion of air, also with the size of air valves, passages, and pipes. Other things being equal, the volume of gas used will vary with the pressure and temperature of both the gas and air. A gas engine should be guaranteed to give a H.P. on a given number of heat units with a given fuel. The day has passed when gas-engine guarantees can be made, accepted, and paid for, on "so many feet of gas per H.P.," and nothing more. W. R.

709. *High-Furnace Gases for Power.* **B. Donkin.** (Engineer, 88. pp. 509–510, Nov. 24; 561–562, Dec. 8; 588–590, Dec. 15, 1899.)—These articles give a description and general plans of some large gas engines adapted to use high-furnace gases. The Oechelhaueser gas engine, with two pistons working in opposite directions in one cylinder, is similar to the Atkinson "Differential." At the Hörde Ironworks in Westphalia a 600 H.P. Oechelhaueser motor, made by the Deutsche-Kraft Gesselschaft, consists of two single-cylinder engines each of 300 H.P. at 135 r.p.m. Each cylinder is 19 inches diameter, and 31·5 inches stroke with pistons. A 1,000 H.P. engine of this type, with two cylinders and four pistons, is being erected at Fishershütte, near Hanover.

The Simplex engine of Delamare-Deboutteville and Malandin to work with high-furnace gas is made by the Société Cockerill, at Seraing, in Belgium (see *Revue Universelle des Mines*, vol. 43, 3rd series, p. 113, 1898). In December, 1895, a 4 H.P. experimental engine was started with these waste gases, and was improved to develop 8 H.P. A 200 H.P. single cylinder simplex engine was built in 1897; and tested by Witz on a twenty-four hours' run with blast-furnace gases in July, 1898. The cylinder was 31·5 inches diameter, stroke 3·28 feet, and at 105 r.p.m. gave 181 B.H.P. (French) with mechanical efficiency 85 per cent. The mean consumption was 117·5 cubic feet per B.H.P. hour, and the calorific value of the gas was 110 B.Th.U. per cubic foot. The gases are induced from the top of the furnaces by a Koerting steam-jet and further washed in scrubbers to remove part of the dust; and the charge is compressed in the engine cylinder to 8 atmospheres before ignition by electric spark. Two or three grammes of metallic dust per cubic meter of gas are carried into the cylinder and pass out with the exhaust, equal to 88 lbs. daily for the 200 H.P. engine, which has been working satisfactorily for eighteen months. For simplex engines, each of 550 B.H.P. having single cylinder of diameter 4 ft. 3 in., stroke 4 ft. 7 in., with Riedler valves, are being constructed to drive the blowers direct.

In Germany the Gas Motoren Fabrik, Deutz, make ordinary Otto cycle engines of two cylinders, on opposite sides of crank, up to about 250 B.H.P per cylinder—thus a 500 H.P. plant, has two and a 1,000 H.P. four cylinders. At Oberhausen the furnace gases are cleaned by passing through three coke scrubbers and four purifiers with small coke, but no water is used. In October, 1898, Meyer tested a 60 H.P. Otto motor driven with high-furnace gas (see particulars in *Zeitschrift des Vereines deutscher Ingenieure* vol. 43, No. 16, p. 453). The engine indicated 79·5 H.P. and the B.H.P. was 65·3 with a consumption of 96·7 cubic feet of gas B.H.P. hour. The heating value of the gas in the colorimeter was 105 B.Th.U. per cubic foot, and the heat turned into indicated work 30·2 per cent. These results are better than those obtained in ordinary practice. In England the work done hitherto with high-furnace gases has been chiefly experimental. At the Glasgow Ironworks, Wishaw, a 30 H.P. Acme gas engine, started in 1895, and the consumption is 95 cubic feet of high-furnace gas per B.H.P. hour. The furnace is fed with Scotch splint coal, and the waste gases have a heating value of 98 B.Th.U.

per cubic foot. The engine, tested by Booth while driving a dynamo, gave 1 E.H.P. hour per 1¼ lb. of coal fed into the furnace, and consumed about 140 cubic feet of gas per E.H.P. hour. A plant of 160 H.P. has been working at Barrow-in-Furness.

Plans are given of a 580 H.P. two cylinder motor, built by Crossley for producer gas; also of a 250 B.H.P. Stockport gas engine to work with coke-oven gas; and of a Premier single cylinder gas engine of 250 B.H.P., the first large power engine built to utilise high-furnace gases in England. (See 1900, Abstract No. 297 ; also in 1898, No's. 991, 992, and 993.) W. R.

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710. *Stresses in Steam Engines, with Special Reference to Electric Traction.* (Elect. Rev. 45. pp. 375–376, and p. 458, 1899.)

711. *Influence of Electrical Developments upon Steam Engineering.* **W. Ripper.** (Mech. Eng. 4. pp. 770–772, Nov. 25, 1899. A lecture delivered before the Sheffield Society of Engineers and Metallurgists on Nov. 13, 1899.)—The author describes improvements in the construction of steam engines and boilers to suit the conditions of electric lighting and transmission of power by electricity. He discusses super-heating by means of a reducing value, the air supply to boiler furnaces, and the working loads on generating stations. J. T. R.

712. *Condensers.* **S. Payne.** (Indus. and Iron. 27. pp. 331–332, Nov. 17, 1899.)—Paper read before the Manchester Society of Junior Electrical Engineers, Oct. 31, 1899.

713. *Complete Heat Cycle for the Steam Boiler and Engine.* **L. C. Auldjo.** (Indus. and Iron. 27. p. 427, Dec. 29, 1899.) Paper read before the Engineering Association of New South Wales.

714. *George Richard Autocar.* (Automotor Journal, 4. pp. 113–114, Dec., 1899.)—A general description of mechanism employed. The speed at which the governor controls the motor is adjustable by the driver. A. G. N.

715. *Motor Starting Device.* (Automotor Journal, 4. p. 122, Dec., 1899.)—A description of mechanism devised by E. Estcourt for enabling the driver to start an internal combustion engine from his seat on a motor-car. A. G. N.

716. *Entropy-Temperature Diagram of a Gas Engine.* **H. T. Eddy.** (Mech. Eng. 5. pp. 50–53, Jan. 13, 1900. Paper read before the American Society of Mechanical Engineers, Dec., 1899.)—This paper describes a graphical method of constructing the entropy-temperature diagram of a gas or oil engine when its indicator card is given. A. S.

717. *Steam-Driven, Water-Power Electric Plant.* (Amer. Electn. 11. p. 581, Dec., 1899.)—Description of plant at City of Columbus pumping station. J. T. R.

718. *Coke as a Steam Fuel.* (Indus. and Iron, 27. p. 283, 1899.)—Suggestions as to management of coke fires. J. T. R.

719. *Oil and Grease Extractors.* (Amer. Electn. 11. pp. 573–575, Dec., 1899.)—An illustrated description of several well-known types.

720. *Measurements in Testing Steam Plant.* (Mech. Eng. 5. pp. 113–116, Jan. 27 and 149–151, Feb. 3, 1900.)

721. *Trials of Two Pumping Engines.* (Engineer, 89. pp. 150–153, Feb. 9, 1900 —*Report by* W. C. Unwin to Leeds Corporation.

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722. *Sherrin Accumulator.* (Elect. Engin. 24. pp. 724–725, Dec. 8, 1899.) —Illustrations are given showing the arrangement of this cell and the construction of its electrodes, but no definite particulars are supplied of its electrical capabilities. E. J. W.

723. *Majert Accumulator.* **A. Wilke.** (Elektrotechn. Ztschr. 20. pp. 783–786, Nov. 9, 1899.)—The chief feature of this accumulator, which is constructed by the Akkumulatorenwerk Oberspree Company, lies in the construction of the positive plate, to a description of which the greater part of the paper is devoted. The negative plate is of the Faure type, and is made in two forms, intended for stationary and travelling batteries respectively. The positive is a deeply chamfered or grooved plate of rolled lead, and is "formed" without a previous coating of oxide being given. Diagrams of this plate, and of the machinery specially devised for its construction, are given in the paper, as also is a table of the weight, capacity for different times of discharge, &c., of the various forms of the cell. N. L.

724. *Hartmann and Braun Electricity-Meter.* **Görner.** (Elektrotechn. Ztschr. 20. pp. 878–879, Dec. 14, 1899. Report read before the Elektrotechnische Verein Mannheim-Ludwigshafen, Oct. 25, 1899.)—This meter is due to Bruger, and is one of the kind in which a rotary magnetic field is produced by the mutual action of two alternating fields arranged at an angle of 90° to each other, and having a similar difference of phase. The field-magnet is E-shaped, of laminated iron, with two diametrically opposite pole-pieces excited by shunt coils, and an inner one, at 90° thereto, excited by a series coil. In the space between these three pole-pieces turns an aluminium drum over a stationary iron core which almost short-circuits the magnetic field. The drum-arbor bears a damping-disc rotating between the poles of permanent magnets. The difference of phase is produced by a transformer and a regulating resistance. The original paper is accompanied by a photograph of the instrument, and contains a very full discussion of the theory of its action. C. K. F.

725. *Tests of the Batault Energy Meter for Alternating Current Circuits.* **C. E. Guye.** (Écl. Électr. 21. pp. 290–295, Nov. 25, 1899.)—A first series of tests of this meter was taken with a view to verifying the law of proportionality for various loads. The percentage errors from mean value were as follows: For 1 lamp, + 0·56; for 2 lamps, — 0·25; for 5 lamps, + 0·22; for 10 lamps, — 0·09; for 15 lamps, — 0·25 (120 volts, 50 periods). Tests are also given for inductive loads. The meter is simple and not subject to derangement. W. G. R.

726. *Maximum Demand Indicators.* **L. J. Steele.** (Elect. Rev. 46. pp. 4–6, Jan. 5, 1900.)—This is a full description of the Halsey maximum-demand indicator, the principle of which is as follows: The rotating part of the supply meter drives the brake portion through the medium of a flexible spring coupling in the spindle, which is severed at that point; a pawl and ratchet serves to prevent relaxation of the spring coupling, and

a viscous material is employed at the junction of the two shafts to act as a retarding agent and to permit of sluggish action. The angular displacement of the armature, relatively to the brake disc, is shown by a pointer fixed to the upper half of the spindle. The device is virtually a recording transmission dynamometer. It is compared in detail with the Wright maximum demand indicator, and also with an arrangement, very similar to itself, described by Wilson in a paper read before the Northern Society of Electrical Engineers, March 8, 1897. E. D. P.

727. *Insulation of Bare Conductor Resting on a Glacier.* **J. Janssen.** (Comptes Rendus, 129. pp. 993–996, Dec. 11, 1899.)—This note is a record of some experiments carried out by Lespieau and Cauro on the behaviour of a bare wire of galvanised iron which is allowed to rest on the surface of a glacier. The wires used were each about 1,700 metres long, 3 mm. in diameter, and were kept 5 metres apart. The result of the experiments is to show that the wires may, for all practical purposes, be considered as perfectly insulated. A. H.

728. *Substitute for Indiarubber.* **W. F. Reid.** (Soc. Chem. Ind., Journ. 18. pp. 972–976. Discussion, pp. 976–977, Nov., 1899.)—A short account is given of the world's production of indiarubber and guttapercha. The composition and properties of an artificial substitute ("velvril") are described. This consists of nitrated castor or linseed oil mixed into a homogeneous mass with nitrocellulose. It burns slowly, and is not explosive. The hardness can be varied with the composition. This material is more stable than either indiarubber or guttapercha. Details of its specific insulation or dielectric strength are not given. It can be applied to wire either as tape or through a covering press. Its use for machine belting, hosing, cementing, varnishing, and for various special processes was described. A discussion followed. L. B.

729. *Cable Core Design.* **F. Breisig.** (Elektrotechn. Ztschr. 20. pp. 842–845, Nov. 30, 1899. Communication from the Kaiserl. Telegraphen-Versuchsamt.)—Various types of core are compared with regard to the "speed" at which legible signals can be transmitted through them. It is assumed that resistance and capacity cannot be reduced without increase of cost, and that a possible way to improve transmission is to introduce self-induction into the core, either by one of the various devices suggested by S. P. Thompson, or by combining iron wires or iron tape with the copper conductor. The lengths experimented upon were comparatively short—not exceeding 500 metres. The conductors in each case were insulated with three coats of guttapercha, sometimes sheathed with steel wires. Alternating currents of known periodicity and of simple sine form were used to represent the working conditions of telegraphy; it is, however, pointed out that the sine form does not accurately correspond to the impulses transmitted through cables. Calculations of the self-induction are based upon the measurement of the alternating volts between the ends of the core and the corresponding alternating current in the conductor. Volts are measured by a compensation method (*Ibid.* p. 448 1891); current is measured similarly, using either a telephone or an electro dynamometer. The telephone is for this purpose extremely sensitive fo 230 ∿ and upwards. For lower frequencies the electrodynamometer give the best results; it is of service even down to 50 ∿ . But since the zer *reading* of the electrodynamometer does not, under the circumstances of

"compensation" method, correspond to a unique relationship between the currents in its respective coils, its indications must be interpreted with caution. Zero may either mean no current or 90° phase difference. As a criterion, a self-induction bobbin connected in series with the fixed coil and provided with a short-circuiting key is employed. The first results relate to the measurement of the capacities of the cables at different frequencies. As the frequency increases from about 270 ∿ to about 580 ∿, the capacity appears to vary something like 2·5 per cent., sometimes an increase, and sometimes a decrease, according to the type of conductor. Similar results are obtained for the impedances and the apparent resistances of the cores at different frequencies; at frequencies from 234 ∿ to 427 ∿ the apparent resistances are approximately three times the ohmic resistances. The measurements relate (1) to a core whose conductor consists of a round copper wire 2·8 mm. diameter covered spirally with four iron strips in one layer to 4·46 mm. diameter, insulated to 11·59 mm., the whole being sheathed with steel wires: the self-induction, as measured, = 0·00370 per km.; and (2) to a core whose conductor consists of a central round copper wire 3·10 mm. diameter, stranded with nine copper wires and three iron wires, each 0·8 mm. diameter, insulated to 11·76 mm., and sheathed with steel wires: the self-induction, as measured, = 0·00262 per km. In another case (3) a central copper wire 2·8 mm. diameter is stranded with ten copper wires each 1·0 mm. diameter, insulated to 11·66 mm. and sheathed with steel wires: the self-induction, as measured, = 0·0235 per km. The self-induction of (1) is thus 1·57 times that of (3). The capacities of (1), (2), and (3) are respectively 0·221, 0·236, and 0·212 mfds. per km. The resistances are respectively 1·124, 1·112, and 1·125 ohms. These figures show that, in order to keep the resistance approximately the same, the diameter of the conductor has been increased in the case of the strands containing iron, with consequent increase of capacity. Taking these factors into consideration, the maximum increase of "speed" due to the iron in the strand, assuming a true sine-form current, is estimated at 8 per cent. The author therefore concludes that it is impracticable by any self-inductive device effectively to improve the speed of signalling. R. A.

730. *Supplements to Railway Signalling.* (Elect. Rev. 45. pp. 1061-1063, Dec. 29. 1899.)—This is an illustrated description of Brierley's Signalling Apparatus, which can be used during fogs when the ordinary signals cannot be seen. The system is one which depends on the movement of normally balanced levers, fixed on the engine, by impact with obstructions placed on the side of the line; this gives rise to appropriate indications, on the engine itself, of the positions of the ordinary signals. The movement of the levers is made to close electrical circuits on the engine, and the indications are given by the ringing of an electric bell and the appearance of discs, which convey the information desired. W. G. R.

731. *Synchronising Phase Indicators.* **W. Ritter.** (Elektrotechn. Ztschr. 21. pp. 7-10, Jan. 4, 1900.)—The author gives a detailed account of various arrangements for paralleling three-phase generators, whereby it becomes possible to find out whether the speed of an incoming machine is too low or too high, and to ascertain the phase relation when the speed of synchronism has been reached. The principles underlying these methods have already been noticed in Abstracts Nos. 892 and 1774 (1899). A. H.

732. *Motor-driven Machine Shops.* **R. T. E. Lozier.** (Cassier, 17. pp. 158-165. Dec., 1899.)—Great economy is obtained by the facility with which

the men can adjust the tool speeds without changing pulleys, the result being that the best speed is adopted and not any speed that is good enough. Absence of belts is sanitary. Power is saved by avoiding slip and countershafts. Time is saved by arranging the machines regardless of alignment in the order taken by the work. M. O'G.

733. *Electric Drawbridge.* **W. S. Key.** (Elect. World and Engineer, 34. pp. 969–970, Dec. 23, 1899.)—The bridge and approaches over the Charles River, Boston, are 1,920 feet long, of which 1,090 feet is over water. The width of the bridge is 100 feet, and consists of two roadways, one above the other, allowing four car tracks in pairs. The draw span is 260 feet, and rests on a central pier, giving free passage for vessels 50 feet wide. The air and hydraulic pumps are worked electrically. The draw is opened by two 28 H.P. motors, and is operated about twelve times every twenty-four hours. M. O'G.

734. *Electrical Operation of Watertight Bulkhead Doors.* **R. M. Watt.** (Elect. World and Engineer, 34. pp. 895–896, Dec. 9, 1899. Paper read before the Society of Naval Architects and Marine Engineers.)—The system devised by F. T. Bowles is described. Each door is provided with a separate motor and power circuit, and can be independently operated by hand. The door is of steel plate riveted to a frame which slides in guides; the surfaces nearest the bulkhead are scraped to fit, and are forced together by wedges in the last half-inch travel. A bronze rack is bolted to the door, gearing through a pinion with another pinion keyed to the shaft of two worm wheels; a worm driven by a motor on the other side of the bulkhead gears with one of the wheels. The motor is of 1 H.P., compound wound. A switch fixed by the door is so arranged that the door may be opened or closed from either side of the bulkhead, or closed from a distant station; a limit switch cuts off the current when the door reaches either of its extreme positions. Sprague solenoid gravity controllers are also provided to throw in either the series or the series shunt windings of the motor. To open or close the door by hand through 6 or 12 inches of coal requires from 75 to 85 seconds; these operations are done electrically in 8 to 9 seconds, and require from 3 to 24¼ amperes at 115 volts. Signal lamps are used to indicate at the distant station when the door is completely closed or opened. A. H. A.

735. *Electrical Machinery in the United States Navy.* **J. J. Woodward.** (Elect. World and Engineer, 34. pp. 813–818, Nov. 25; 853–855, Dec. 2; 891–895, Dec. 9, 1899. Paper read before the Society of Naval Architects and Marine Engineers).—This paper describes in detail, with numerous illustrations, the electrical plant installed on the battleships *Kearsarge* and *Kentucky*. All the auxiliary machinery on these vessels, except that connected with the main engines, is thus driven; the types of electrical machinery used are developments of those employed, to a less extent, on other vessels. Electrical driving is being applied on warships building for a foreign navy to a still greater extent. The duties performed electrically are tabulated, and the generating machinery, which consists of seven 50 kw. dynamos coupled to vertical compound high-speed engines, is described in detail. Shaft governor and forced lubrication are employed. The main switchboard is arranged fo a three-wire system with 160 volts between the outers, with separate 'bus bar for lighting, power, and working the turrets. An equaliser board is provide for running the dynamos compound-wound in parallel. The arrangement

distributing boards, both for power and lighting, and of the circuits, which are divided into "battle" and "normal," are described; a mixture of insulator, conduit, and wood-casing work is used for installing the conductors, according to their situation.

Three types of motor controller are used. The R controller is for reversing and controlling the speed by the rheostatic method. The B controller for hoisting is arranged like the R type on one side, but instead of reversing on the other side it connects the rheostat across the mains and shunts the armature to a larger or smaller portion of it; the effect of this is that small loads may be lifted at suitable speeds, or the arrangement may be used as an electrical brake for lowering. The P controller is used for rotating the turrets on the Ward Leonard variable voltage system. Each turret is operated by a separate generator, the field of which is varied by the controller; the motor fields are excited at constant pressure, so that the speed of rotation varies as the strength of the generator field, with constant torque. The direction of rotation is likewise varied according to the polarity of the generator field by the controller, which also provides electrical braking. Two 50 H.P. motors are fixed in each main turret, coupled by a shaft, and driving through bevel and worm gear. Controlling panels are used for fan motors and chain ammunition hoists, containing shunt rheostats for speed regulation, and automatic safety starting switches. Electrical brakes are used on the hoists. Each boat crane is fitted with a 50 H.P. motor, and can lift 18,000 lbs. at 25 feet per minute, with two motions, hoisting and turning. A special description in detail is given of the motors, which are generally shunt wound, and run at 400 r.p.m. All but the fan motors are of the enclosed four-pole type. Other auxiliaries are described, of various types. Two of the six deck winches are provided with two-speed gears, giving a lift of 2,200 lbs. at 300 feet per minute, or 13,000 lbs. at 50 feet per minute. Other electrical fittings are signalling apparatus, truck lights, diving lanterns, &c. A. H. A.

REFERENCES.

736. *Testing Electric Supply Meters.* **C. A. L. Prusmann.** (Elect. Engin. 23. pp. 38–40, 102–105, 166–167, 230–231, 340–341, 462, 590–591, 730–731, 1899.)—In this series of articles there is first described the most advantageous arrangement of the meter-room and store-room, the position and details of the benches, shelves, cupboards, lights, &c., illustrated by a plan. The labelling of the meter by the supply company or corporation is then described, this being followed by the details of a convenient system of book-keeping, comprising a series of forms for the various books, &c., employed. The arrangement of connections, terminals, and circuits is then considered at considerable length, this being followed by a detailed illustrated description of the resistances and instruments used. The whole question is dealt with in a very detailed manner, looking at it from the practical side. C. K. F.

737. *Switchboard Connections and Synchronising Arrangements for Polyphase Generators.* (Amer. Electn. 11. pp. 509–512, Nov., 1899.)

738. *Concentric House-Wiring.* **J. D. F. Andrews.** (Elect. Rev. 45. pp. 576–577, and pp. 613–615, 1899.)

739. *Electrical Specifications.* **E. K. Scott.** (Elect. Rev. 45. pp. 543–544, 1899.)

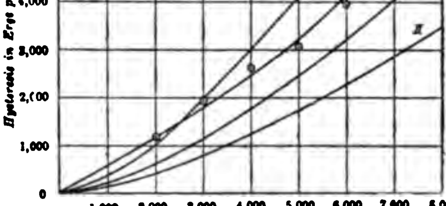
740. *Electric Welding as Used on the Russian Railways.* (Zeitschr. Elektrochem. 6. pp. 286–292, Nov. 16, 1899.)—Report read before the Association des Ingénieurs Électriciens, Liège.

GENERATORS, MOTORS, AND TRANSFORMERS.

741. *Compensated Revolving Field Generators.* **H. G. Reist.** (West. Electn. 25. pp. 809–810, Nov. 25, 1899. Paper read before the Ohio Electric Light Association, Oct. 11, 1899.)—This is a method of automatically adjusting the potentials of alternators for all variations and degrees of inductive or non-inductive load.

The shaft of the alternator which carries the revolving field also carries the armature of the exciter, which has as many poles as the alternator, so that the two operate synchronously. Besides the exciter commutator and the pair of collector rings which deliver the current to the field of the alternator, the shaft also carries three other collector rings, which are connected to taps in the exciter winding, in the same way as the rings are connected to the windings of rotary converters. Through these rings the exciter receives current from one or several series of transformers inserted into the lines leading from the alternator. This alternating current, passing through the exciter armature, reacts upon the exciter field, and in consequence the voltage of the exciter is due to the combined effect of the shunt field and the magnetic reaction of the alternating current. This current passes through the exciter in such a manner as to give the necessary rise of exciter voltage as the non-inductive load increases, and without other adjustment to give a greater rise of exciter voltage with additions of inductive load. W. G. R.

742. *Hysteresis in Armature Cores.* **F. G. Baily.** (Electrician, 44. pp. 323–324, Dec. 29, 1899.)—In this article the results are described of some experiments on testing the hysteresis of armature cores. A 5 kw. two-pole dynamo was used, the armature of which was 10 inches long, $6\frac{3}{8}$ inches diameter; the discs were $\frac{1}{40}$ inch thick and fitted the spindle closely. Special precautions were taken to eliminate frictional errors. Corrections having been made for eddy currents, the values plotted in Curve I. of the following diagram were obtained :—



The same iron could not be tested by the ballistic method, but Curve I gives the values obtained by A. J. Ewing for soft charcoal iron in an alte*nating* field, showing much lower hysteresis than with the rotating fie *Curves III. and IV.* are the results of tests made on samples cut from t

same sheet, in a rotating and an alternating field respectively, showing similar results. The author found that the change in hysteresis-loss, due to mechanical vibration of the core, was negligible. In a non-uniform field, as in the case of slotted cores, the hysteresis value approaches that due to an alternating field. The conditions in a shallow ring armature probably produce an intermediate value of the hysteresis loss. A. H. A.

743. *Armature Windings.* **F. Emde** and **S. Olsen.** (Écl. Électr. 21. pp. 321–327, Dec. 2, and 369–375, Dec. 9, 1899.)—An elaborate examination of the conditions which must be fulfilled in order that a multiple armature winding may be possible. A. H.

744. *Compound Field Winding.* (Elekt. Runds. 17. pp. 56–57, Dec. 15, 1899.)—A description of a new form of compound field winding for dynamos or motors used by the Helios Company. The field magnet consists of a continuous iron ring with ring- or drum-wound exciting coils in slots or holes, resembling the stator of an induction motor, the compound turns being wound in the spaces between the shunt coils. A complete neutralisation of armature reaction is thus obtained and sparkless running at all loads with fixed brushes, the air-gap being reduced, thus increasing the efficiency. Such compound dynamos can be used for cell-charging without fear of reversal. L. B.

745. *Commutator Design.* **A. D. Adams.** (Amer. Electn. 11. pp. 568–570, Dec., 1899.)—Emphasising the importance of good commutator design, the author ascribes the majority of failures to mechanical rather than electrical defects, and discusses the details of construction. Usually with carbon brushes the width of brush may equal that of two segments, with a current density of 30 amperes per square inch of contact surface. Recent practice favours large diameters and short, wide segments rather than long and narrow bars. It is important that the taper of the segments, which depends only on their number, should be accurate. Mica insulation varies from 0·02 to 0·06 inch in thickness, and should not be so hard as to wear less quickly than the metal. The conical clamps which bind the segments together are preferably fixed to the sleeve with screws, instead of a nut. Details of the design of a small commutator are given, with illustrations. A. H. A.

746. *Advantages of Induction Generators.* **M. Leblanc.** (Écl. Électr. 21. pp. 328–332, Dec. 2, 1899.)—The first part of this paper is devoted to a discussion of the difficulties which are at times experienced in running alternators in parallel, the phenomenon of hunting being more particularly dealt with. In the second part the author proposes to get over the trouble of having to run synchronously by the use of induction generators, one of which would be provided with the special form of exciter designed by the author (see 1899, Abstract No. 908), and would thus determine the frequency and the P.D. of the supply, while the remaining generators would not in any way differ from ordinary non-synchronous motors. The paralleling of such machines would present no greater difficulty than that of continuous current dynamos. In the third part of his paper the author suggests a method of power transmission at constant (alternating) current, by means of induction generators coupled *in series*. It thus appears, according to the author, that by the introduction of induction generators we should get rid of all the peculiar difficulties attending the use of alternating currents, while at the same time retaining all the advantages of continuous-current working. A. H.

747. *Advantages of Two-Phase Generators.* **H. Girgensohn.** (*Zeitschr. Elektrotechn.*, Wien, 17. pp. 624–627, Dec. 10, 1899.)—In this paper the author endeavours to justify the more general use of two-phase machines instead of single-phasers in cases where nowadays the latter only are employed. For a given type and size of machine, a two-phase winding corresponds to an output which is about 30 per cent. greater than that of a single-phase winding. If the two circuits of a two-phaser are linked together, and the machine used as a single-phaser, its output is practically the same as that of a single-phaser of the same size and type. Such a machine would probably run well in parallel with ordinary single-phasers. But in addition to this, it might be used for supplying power to two-phase motors, in which case its output would be increased by some 30 per cent. For supplying two-phase motors, a third wire, connected to the junction of the two windings, would be required. Thus it might appear at first sight as if a heavier outlay of copper in the mains were necessitated by the use of two-phase motors. The author points out, however, that the average power of motors connected to town mains amounts to 1¼ H.P., and that for motors of this size the single-phase type has a power-factor of 0·7 and an efficiency of 67·2 per cent., while for the two-phase one the corresponding figures are 0·78 and 73·6 per cent. When these facts are taken into consideration, as well as the much larger starting current taken by single-phase motors, it appears that the balance in favour of the latter type as regards total cross-section of copper in mains approaches the vanishing-point.
A. H.

748. *Drop of Potential in Alternators.* **B. A. Behrend.** (Elektrotechn. Ztschr. 20. pp. 837–840, Nov. 30, 1899.)—Two methods are in use for determining the P.D. across the alternator terminals when supplying a current I to a *highly inductive* circuit, the open-circuit characteristic (exciting current—E.M.F.) and the short-circuit one (exciting-current—short-circuit current) being supposed known. If i is the exciting current, E and I_0 the E.M.F. and short-circuit current respectively corresponding to it, then according to method (1) the P.D. across the terminals is given by $V=E\left(1-\frac{I}{I_0}\right)$. According to method (2), on the other hand, if i_0 stand for the exciting current required to produce the short-circuit current I, the *effective* exciting current is supposed to be $i-i_0$, and if the E.M.F. corresponding to $i-i_0$ is E_0, then E_0 is the terminal P.D. By comparing the calculated values of the P.D. with those actually obtained for a number of alternators the author arrives at the conclusion that, although in some cases both methods give results which differ widely from those obtained experimentally, yet whereas method (1) is of considerable value to the designer in most cases, method (2) may be considered worthless.
A. H.

749. *Alternating-Current Machinery.* **M. Leblanc.** (Écl. Électr. 20. pp. 171–178, 205–211, 253–261, 292–296, 404–413, 447–456, and 498–506, 1899.) —A continuation of the elaborate series of papers some of which have already been noticed in these Abstracts. The author further considers the theory of induction generators, and the conditions for their satisfactory working. Next comes the question of the excitation of asynchronous motors by means of the special device suggested by the author. This is followed by a long description and a mathematical theory of the special forms of rectifying transformers designed by the author.
A. H.

750. *Parallel Running of Alternators.* **G. Benischke.** (Elektrotech

Ztschr. 20. pp. 870–878, Dec. 14, 1899.)—In this paper the author reviews in detail the various conditions required for successful parallel running. He points out that there are two distinct kinds of equalising current possible: the one, which is mainly an idle current, is due to unequal excitation of the machines, and may be removed by proper adjustment of the excitation; while the other represents power, and is due to speed fluctuations. The latter kind of equalising current may sometimes be removed by proper adjustment of the governor. The author next considers the disturbing elements which may be introduced under various conditions of working. In the case of direct-coupled generators difficulties may arise if the torque exerted by the engine is not sufficiently uniform, and if the machines happen to be thrown into circuit when the relative positions of their cranks are different. If under these circumstances it is permissible to interpose a choking-coil between the machine and the 'bus bars, the equalising current may be readily reduced. Another case which presents difficulties is that of a direct-coupled alternator driven by an engine whose torque is not uniform, and supplying power to a rotary converter. The only remedy in this case is again the interposition of a choking-coil. Large equalising currents may occur even in the case of belt, rope, or turbine-driven alternators if their E.M.F. waves differ considerably in shape; the frequency of such currents being a multiple of the fundamental frequency. The author finally discusses the troublesome phenomenon of the hunting of alternators. He refers to Kapp's paper on this subject (see 1899, Abstract No. 1085), pointing out that the resonance theory propounded by Kapp does not accord with observed results. He explains the phenomenon as an *interference* effect produced by the superposition of two or three consecutive waves of different frequency; the resulting "beats" fully account for the observed alternate increase and decrease in the equalising current. He further states that if Kapp's resonance theory were correct, then the introduction of even a small inductance would suffice to upset the conditions required for resonance; in practice it is found, however, that a small inductance produces no appreciable effect. The time of a complete oscillation of the armature (the oscillation being superposed on a uniform motion of rotation) is given by

$$t=2\pi\sqrt{\frac{M}{T}}$$

where M is the moment of inertia and T the greatest torque which could act on the armature (*i.e.*, the torque corresponding to a phase-displacement of $\frac{1}{4}$ period from the position of synchronism). The author states that as neither M nor T can be predetermined with any degree of accuracy, he does not believe that it is possible to predict whether hunting will take place or not. An ingenious mechanical model is described to illustrate the phenomenon of hunting. A. H.

761. *Enclosed Electric Motors.* **S. F. Walker.** (Elect. Rev. 45. pp. 956–957, Dec. 15, 1899.)—The author cites experiments proving that sparking at the brushes of a motor cannot ignite explosive gaseous mixtures, but states that colliery owners insist on the commutators being boxed in; he then discusses the advantages and drawbacks of the enclosed type of motor.

A. H. A.

762. *Rotary Converters.* **E. Wilson.** (Instit. Elect. Engin., Journ. 28. pp. 287–298, 1899.)—The machine experimented upon was a Siemens two

pole dynamo furnished with four contact-rings connected to the commutator at four points 90° apart. It was used for transforming two-phase currents into a continuous current. The two-phase currents were supplied by a couple of similar alternators mechanically coupled so as to have their E.M.Fs. in quadrature with each other. Curves are given in the paper for the P.D. and current waves under varying conditions of load and excitation. The mechanical phase displacement of the converter armature was also studied, by connecting in series two instantaneous contact-makers, one of which was mounted on the alternator shaft, and the other on that of the converter, and introducing the two contacts into a circuit consisting of a battery and reflecting galvanometer. The distribution of the magnetic flux in the air-gap was examined by means of a double brush, making contact with two neighbouring commutator segments; curves showing the field distribution under various conditions are given, the most interesting being that obtained when the field of the converter was not excited, so that the flux was entirely due to the currents circulating in the armature. It was found in this case that the air-gap under each pole-piece could be divided into two regions in which the magnetic flux was of opposite sign. When run on a single phase the converter was found to drop out of step more readily, and the sparking at the brushes on the continuous-current side was much greater. A. H.

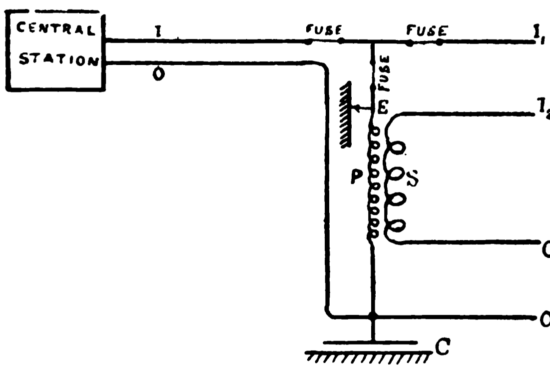
753. *Study of Rotary Converters.* **E. de Marchéna.** (Écl. Électr. 19. pp. 108–115, 1899; Industrie Électrique, Feb. 10 and 25, p. 58, 1899. See 1899, Abstract No. 506.)—In this paper the author studies the special case of a rotary converter the P.D. across whose terminals is required either to decrease or else to increase with increase of load. In the first case a shunt winding is sufficient for exciting the machine; in the second, a series winding with or without a shunt winding is required. Assuming that the limits between which the load may vary and the corresponding limits of P.D. are given, and that the connection between the resultant ampere-turns acting on the field and the E.M.F. is known (a straight-line relation being assumed within the given limits of P.D.), the author develops an elaborate analytical and graphical treatment of the problem, by means of which the variation of the P.D., the power-factor, and the angle of lag between the current and E.M.F. of the alternator supplying the converter, may be studied, as the load varies between the given limits. A. H.

REFERENCE.

754. *Starting and Regulation of Motors.* **C. F. Guilbert.** (Écl. Électr. 21. pp. 401–412, Dec. 16, 1899.)—Patents in connection with alternate current motors, rectifiers, &c.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

755. *Cable Breakdowns.* **G. Kapp.** (Elektrotechn. Ztschr. 20. pp. 896–900, Dec. 28, 1899.)—Soon after the establishment of the first alternating-current central stations with networks of concentric cables it was found that the switching on or off of sections of the cables was attended with the danger of a breakdown in the insulation between the outer main and the lead covering. It was also found that this danger could be avoided by following Neufeld's rule of always switching on the outer conductor first, and switching it off last. Breakdowns of the kind considered are due to resonance phenomena, and the author fully investigates the conditions under which they become possible. He first considers the case of a concentric cable running out from the central station and supplying a transformer which feeds an isolated portion of the secondary network. Let C_1 stand for the capacity of the outer conductor with respect to the lead covering (*i.e.*, with respect to earth), and C_2 for the capacity, also with respect to earth, of the outers of the entire remaining portion of the network supplied from the same station. If



we suppose that the station end of the outer conductor of our cable is disconnected while the inner still remains in contact with its 'bus bar, a current will flow as follows: From the 'bus bar through the inner conductor and the primary coil of the transformer to the outer conductor of the cable, thence (as a displacement current) through the condenser of capacity C_1, next through the condenser of capacity C_2, and finally along the outer member of the remaining portion of the network to the station. Since C_1 and C_2 are joined in series, their joint capacity is $C_1C_2/(C_1+C_2)$, and if C_2 is very large in comparison with C_1, this becomes practically equal to C_1. It is obvious that since we have an inductive circuit (the primary of the transformer) connected in series with the condenser, powerful resonance may under certain conditions set in, and the dielectric of the cable be pierced. By considering some special cases such as frequently occur in practice the author finds that resonance is not at all unlikely to take place, and that the danger of breakdown is a very serious one. A similar investigation with respect to stranded cables shows that in their case the danger is much less than with concentric cables. To avoid all risks of breakdown the author recommends: (1) A strict adhesion

to Neufeld's rule; (2) Earthing of the outer conductor at a single point; (3) Omission of all safety fuses on the outer. Another class of breakdowns is then considered by the author. This has only been known to occur in networks of concentric cables whose inner and outer members respectively are all connected together both on the primary and on the secondary sides. The breakdown is brought about not by the disconnection of the outer conductor, as in the first case, but by the development of an earth on the inner conductor. It is said that a breakdown of this second kind is much more serious than one of the first kind, the insulation being generally pierced in a number of places simultaneously. The accompanying diagram explains how the breakdown is brought about. P and S stand for the primary and secondary of the transformer, I and O for the inner and outer conductors respectively. Let an earth occur at E. All the fuses shown will blow, but the transformer, being still across the secondary network, will receive a current, so that P will be the seat of an E.M.F. which will give rise to a current flowing to earth, thence through the capacity C (that of the outer member O_1 of the network), and back to P. Resonance in this circuit may occur under certain conditions, with a consequent breakdown of the insulation between O_1 and the lead sheathing. In this case the only reliable protection is to earth the outer at a *single* point (in order to avoid disturbance of neighbouring telephone circuits, and through a non-inductive resistance to prevent the occurrence of a dead short-circuit in case of accident), and leave out all safety fuses on the outer. A. H.

756. *Grounding of Low-tension Circuits.* **W. L. R. Emmet.** (Elect. World and Engineer, 34. pp. 738-739, Nov. 11, 1899.)—The author refers to the article by W. B. and L. C. Reed (see 1900, Abstract No. 317) in which the dangers from differences of potential on low-tension mains caused by accidental crossing of a high potential circuit are discussed, and points out that the conditions assumed in their paper would very seldom exist. These conditions are that on a grounded circuit with high resistances between the low-tension mains and between mains and earth, the current in the mains, when crossed by high-potential circuits, would be sufficiently large to cause dangerous potential differences between low-tension mains and between mains and earth.

In the case of a circuit fed from a low-tension distributing network, supplied either directly from the armatures of generators or secondaries of large transformers, the resistances of these apparatus being so low, an enormous current would be required to raise the differences of potential at their terminals to a dangerous degree—in fact, the conductors would probably be destroyed instantly at the points of crossing. Similarly with the grounding connections, which should be of low resistances. The character and number of ground connections for circuits should be governed by rules.

The failure of ground connections, as a safety device, is likely to occur in the event of low-pressure circuit fuses blowing, in which cases a high potential difference may be between the wires of the circuit. This, however, is easily prevented by the arrangement of fuses and ground connections. In the case of a circuit fed from a house transformer, the transformer fuse would afford a sufficient protection in the event of a cross between the two transformer coils.

The author finally points out W. B. and L. C. Reed's method of using a automatic cut-out in the main circuit, actuated by an excess of current throu the ground connections or through a certain connection between the mai has the disadvantage of being slow in action, the damage being done befc

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the cut-out can come into play. This is the drawback of all earthing devices, which, the author states, cannot take the place of permanent ground connections. E. D. P.

757. *Best Number of Feeding-points in a Distributing Network.* **A. Sengel.** (Elektrotechn. Ztschr. 20. pp. 807–809, Nov. 16, and 826–829, Nov. 23, 1899.)—The total cost of a network is made up of the cost of the feeding and distributing systems. By making the number of feeding-points very large the cross-section of the distributors may be greatly reduced, and thus the cost of the distributing system lowered—at the expense of the feeding system. On the other hand, by using a small number of feeding-points the cost of the feeders is reduced, while that of the distributors is increased. It is obvious that for a *given* distributing network there will be one particular number of feeding-points for which the total costs will be a minimum. The author investigates this problem for networks consisting of square, triangular, and hexagonal meshes, and finds that the expressions obtained for the best number of feeding-points are practically independent of the shape of the meshes, but that they depend on whether the network is unbranched (*i.e.*, the feeding-points connected by simple lengths of distributors) or branched (*i.e.*, with a number of distributing *meshes* connecting the feeding-points). The following formulæ are deduced by the author :—

$$F = \left.\begin{matrix}0{\cdot}5\\1{\cdot}0\end{matrix}\right\} \frac{A}{e}\sqrt{\frac{100b}{L\left(m+d+\frac{s}{2L}\right)pk\sigma}}$$

$$l = \left.\begin{matrix}1{\cdot}4\\1{\cdot}0\end{matrix}\right\} \sqrt{e}\,.\sqrt[4]{\frac{L\left(m+d+\frac{s}{2L}\right)pk}{100b\sigma}}$$

where F = number of feeding-points ; A = total output of network, in watts ; e = P.D. at feeding-points, in volts ; $d + ba$ = cost of (single) cable, per metre length, of sectional area a square millimetres ; L = length of (single) feeder ; m = cost of laying a metre length of cable (not including cost of digging trenches or building conduit) ; s = cost of making feeding-point connections, and feeder connections at central station ; p = total percentage drop along double feeder ; k = conductivity of copper (= 57) ; σ = output, in watts, per square metre of network ; l = distance between two feeding-points in metres.

The use of these formulæ is illustrated by a numerical example. The upper figures (0·5 and 1·4 respectively) in the formulæ are to be used for unbranched, and the lower (1·0 and 1·0) for branched networks. Where the load is distributed irregularly, it is best to subdivide the entire network into a number of districts (for each of which σ may be considered as contant) and apply the formulæ to each district separately. A. H.

758. *Electricity as a Motive Power.* **J. S. Raworth.** (Electrician, 44. pp. 41–44, Nov. 3, and 73–76, Nov. 10, 1899. Paper read before the Manchester Association of Engineers, Oct. 28.)—The author compares steam-driven manufacturing works (*i.e.*, with the usual belt, rope, or other gearing transmissions) with electrically driven works, either with supply from outside sources or with electrical generators at the works. Examples are worked out showing the actual costs of the systems, and other general advantages of the two methods are pointed out.

A long appendix of several tabulated results of experiments is added.

including losses in belts and shafting, and tests of machine-tools driven by electric motors. Also tables and curves of efficiency tests of various electric motors, both direct- and alternating-current. E. D. P.

759. *Electric Power in Powder Factories.* (Engineering, 69. pp. 115–118, Jan. 26, 1900.)—A short, illustrated description of the electric power equipment of three new United States Government smokeless powder factories. The power is supplied in each case by Westinghouse double-current multipolar generators, giving both direct current at 500 volts for lighting and traction, and two-phase currents at 400 volts and 60 ∿ (in one case 120 ∿) for power. For the latter purpose Westinghouse C-type induction motors are used, which, having no sliding contacts whatever, reduce the danger of explosion to a minimum. L. B.

760. *Impulse Wheel Generating Plant.* (Elect. World and Engineer, 34. pp. 754–755, Nov. 11, 1899.)—The turbine is designed to work off a pumping main when the supply of water is greater than the demand. The speed of 650 revolutions per minute required for the direct coupled generator necessitated the use of 18-inch diameter impulse wheels; and, in order to obtain 110 H.P. from the turbine, 18 nozzles were required. The turbine is arranged with 6 runners and 3 nozzles to each runner, in order to avoid the expense of 18 contracting nozzles. The regulation is effected by cutting off one jet at a time by ordinary butterfly valves. In this way the efficiency of only the one jet actually being cut off is affected.

The paper is illustrated, and contains a full account of an interesting machine which has been running for over a year at Columbus, Ohio.

M. G. W.

761. *Edinburgh Electricity Works.* (Elect. Engin. 24 pp. 553–556, Nov. 3, and 582–587, Nov. 10, 1899.)—Such rapid progress in electric lighting is taking place in Edinburgh that the Dewar Place works, which can supply 3,000 kw. as a maximum, have been found to be far too small for the extensions required, with the result that a larger site has been acquired, and an entirely new works has been designed by Kennedy. The old works generated energy on a 230-volts, direct-current, three-wire system, and also on a 2,500-volts alternate-current system. The new works will generate only direct current, to be distributed on the three-wire system with 460 volts across the outers. Plans and particulars are given of the new works. There are to be four boiler-houses, each containing nineteen boilers, arranged in pairs on each side of the two engine-rooms. Each of these engine-rooms contains thirteen steam-dynamo sets, each of 1,200 I.H.P., besides the smaller sets of boosters and balancers required. The flues and chimneys of the boiler-rooms are so arranged that sections of the flues can be shut off for cleaning purposes without interfering with many boilers. Two main flues run the full length of each boiler-house, and each of these can be made to discharge into either of the two chimneys, there being two chimneys for each pair of boiler-houses. Three dampers are placed in each of these main flues, one at eacl end and one in the centre, so that, by regulating these, the gases from a bloc of boilers may be led into either of the chimneys, or divided between th two.

The buildings now erected extend over rather more than a quarter of t area the works would occupy were the whole completed. The thirte oilers erected are of the dry-back marine type, each capable, when fed wi

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ordinary grades of Scotch coal, of evaporating 11,500 lbs. of water per hour. Particulars and dimensions of these boilers are given. Automatic stokers are fitted to each, being driven in groups of ten by steam engines. The stokers are fed from the coal-stores, above the boiler-house, through shoots in the floor. The quantity of coal delivered to each boiler is measured by means of an iron box, placed between the shoot from the coal-stores and the hoppers of the stokers. Shutters are placed at the top and bottom of the box; with the lower shutter closed the upper one will be open and the box fills with coal. The shutters are operated together from one lever by the fireman; one motion of the lever will close the upper and open the lower shutter, while the reverse motion will open the upper and close the lower shutter. The box is graduated to hold 5 cwt. of coal when full, a regulating plate being fixed inside, so that its capacity may be varied slightly for changes in weight, due to different sizes of coal. The coal is run from this box through a divided shoot to the hoppers of the two stokers on the boiler. The stokers may be fed direct by hand, and the fires also. A duplicate steam main runs the length of the boiler-house, with branches from each boiler to each main. The ring main of the engine-room is fed from these, separators with Geipel steam-traps attached being placed at the entrance to the engine-room and half-way round the steam-ring. Three Worthington compound duplex feed-pumps are installed, also two Berryman feed-water heaters. Condensing plant is to be installed eventually; the surface system will be adopted.

The main generators are Willan's engines directly coupled to Mather & Platt dynamos. Two of the machines yield 840 amperes at 230 volts, and six larger sets of about 1,200 H.P. are on order. The guarantee figures of the latter are that at full load the steam consumption shall not exceed 17 lbs. per E.H.P., or 15·8 lbs. per B.H.P. hour.

Two sets of accumulators are installed, each consisting of 140 cells of the Pritchetts and Gold type. Their capacity is 2,000 ampere-hours at a 400 ampere rate, or they can give 800 amperes for half an hour on emergency.

The switchboard arrangement is described in full. The usual method of proportioning all feeders so that the same drop shall be obtained with each when at full load has been abandoned. The dynamos, cables, &c., are designed so as to allow for a drop of 100 volts on the long-distance feeders and for a drop of 50 volts on the short feeders. The switchboard is arranged, therefore, so that two distinct circuits can be formed; each may have several machines paralleled on it, and yet one may help the other by motor-driven boosters to equalise the generator loads. E. D. P.

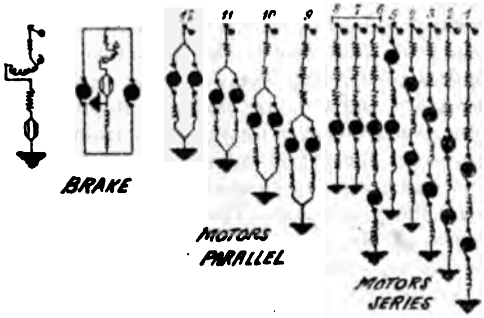
762. *Electric Lighting at Windsor.* (Elect. Engin. 24. pp. 717–719, Dec. 8, 1899.)—A full description of the street lighting is given; both arc and incandescent lamps are used. The incandescent lamps, over 300 in number, are coupled to the mains in a novel manner, the circuits being so arranged that all the lights can be switched on or off from one point in the centre of the town. For this purpose lengths of small subsidiary mains are used in conjunction with automatic relays. Diagrams of the arrangement are given.

The company's charge for the supply and maintenance of each 16-c.p. lamp is £3 12s. 6d. per annum in Eton, and £3 7s. 6d. per annum in Windsor; for each 2,000-c.p. arc lamp £22, and for each 500-c.p. arc lamp £16.

Some particulars are given of tests on a new 200-H.P. Peache engine coupled to a 120 kw. Holmes dynamo. With an output of 162·6 E.H.P. the

engine running non-condensing, was 20·78 lbs. per I.H.P. hour, or 25·3 lbs. per E.H.P. hour. At half-load the steam consumption per E.H.P. hour was about 32 lbs. With full load on and engine running at 428 r.p.m., a rise of 2 per cent. in speed was produced by throwing load off suddenly, the momentary rise being 5 per cent.; with the sudden change of load from full to half an increase of speed of 1·6 per cent. was produced. Specimens of indicator diagrams obtained during the test are given. E. D. P.

763. *Como Electric Tramway.* **R. v. Podoski.** (Elektrotechn. Ztschr. 21. pp. 3–7, Jan. 4, 1900.)—An illustrated description of a tramway equipped by the Helios Company. The line has a short gradient of 6·8 per cent.; full



particulars and tests are given of the brakes for holding the car in check when descending. The controller connections to the two motors are as shown in the accompanying figure. E. K. S.

764. *Isle of Man Tramways.* (Electrician, 44. pp. 458–462, Jan. 26, 1900.) —An illustrated description of a water-driven electric plant installed by the Isle of Man Tramways and Electric Power Company for the generation of power for the Douglas-Laxey and Ramsey electric lines. The power generated, about 140 H.P., is sufficient for the winter or light season load on these lines. The summer load is supplied by steam-driven plant, about 2,200 H.P. being required.

The Laxey River furnishes the power, a working fall of 38 feet being obtained. Some details of the construction of the weir, races, pipe-line, &c., are given. Two 12-inch turbines of the Victor type, one bipolar generator, and one booster are installed. The electrical machines are coupled by clutches to the turbines, which can be also rigidly coupled together. Main connections are made from the switchboard to the main switchboards at the steam-driven stations. The turbine station works in connection with three battery substations, whereby full load is kept on the main generator. E. D. P.

765. *Burgdorf-Thun Three-Phase Electric Railway.* **C. Rochat.** (Street Rly. Journ. 15. pp. 858–860, Dec., 1899.)—The line is 40 km. in length, and at Burgdorf connects with the standard steam road between Berne and Olten, whilst at Thun it runs in connection with the Berne-Thun Interlaken Railroad. In order to make close connection with each of these lines a larger train service was necessary than would have been convenient with steam

power; and again, the grades, though not very steep, would yet have been considerable for steam-operated trains. With electricity, on the other hand, the grades are easily surmounted. Single cars can be run frequently, and by means of three-phase transmission at high voltage, advantage can be taken of a water power at Spies about 10 km. from Thun.

Power Station.—Four turbines, located on the Kander River, operate under a fall of 63 m. with an average volume of 10,000 litres of water per second, equal to 6,300 H.P. Each generator has a capacity of 900 H.P. and produces three-phase current at 4,000 volts, which is raised to 16,000 volts in step-up oil-transformers. The lighting is kept distinct from the power circuit.

Track.—The line is single track throughout, the maximum gradient 2¼ per cent., and the minimum curve-radius 250 m. The rails, 36 kg., are in 12 m. lengths, and the complete track weighs 110 kg. per metre. The rails are bonded by having the under side of head and top of base grooved and filled with zinc, as are also the angle plates bearing upon these parts. Cross-connections are made at 100 m. intervals by 8 mm. wires.

High-tension Line.—The pole line for the 15,000 volt transmission consists of three copper wires, each 5 mm. diameter, carried on porcelain double-petticoat insulators. Between Spies and Thun the wires are carried on latticed poles set in concrete, but along the track the poles are of wood, the maximum span being 35 m. There are Siemens-Halske horn lightning arresters at the entrance to the power station and at each substation, and to avoid short circuits to earth after atmospheric discharges, water rheostats are introduced in the earth connection.

Substations.—There are 14 transformer substations each containing a 450 kw. oil-transformer, having a ratio of 15,000 to 750 volts. The transformers and switchgear, &c., are enclosed in metal housings, surmounted by the overhead construction for the high-tension wires.

Trolley Wires.—These are two in number, 8 mm. diameter, carried 5·1 m. above the track, and 1·1 m. apart. Double insulation is employed between trolley wires and poles, the latter spaced 35 m. apart except at curves. The bow sliding trolley is used, and there are no overhead frogs except at turnouts. At those points where the wires cross, section insulators are installed, and as the cars carry four trolleys, two at each end, contact with at least one set is always secured.

Electric Locomotives.—These are two in number, of the following dimensions: Wheel base 3 m., length of body 6 m., length between buffers 7·2 m., diameter of wheels 1·3 m., and weight complete 28 tons. They are employed principally for freight traffic, and are capable of hauling 100 tons (freight) at a speed of 18 km. per hour on 2¼ per cent. grade, or 50 tons (passengers) at 36 km. per hour. Each locomotive is equipped with two motors of 150 H.P. running 300 r.p.m. at 750 volts. They are placed in the middle of the locomotive, and at either end of the same shaft, the stators being mounted on the locomotive framework.

The rotor shaft can be thrown into gear with either of two trains of gears (for the two speeds) connected with the axles. For facilitating the mounting and dismounting of the rotors, the sides of the locomotives have openings through which the shaft can be removed.

The starting rheostat is composed of helical coils of ribbon, separated into three sections corresponding to the three phases and connected to a commutator fitted with carbon brushes. At each end of the locomotive are two switches, one for making and breaking the circuit, and the other for reversing.

Each locomotive carries a transformer for reducing the pressure from

750 volts to 100 volts. Part of this low-tension current is used for operating a motor compressor of 3 H.P. for the air brake, and part for lighting.

Motor-Cars.—At present there are six motor-cars, each capable of carrying 68 passengers, the weight of the car fully equipped being 32 tons. The following are the leading dimensions: Length of body 12·2 m., width of body 3·05 m., distance between centres of trucks 9·5 m., wheel base 2·2 m., diameter of wheels 1·02 m., and length over all 16·3 m. Four 55 H.P. motors are carried on each car (one to each axle), and they run at 600 r.p.m. with load, and 586 without. The starting rheostat is similar to that on the locomotive, as is also the motor compressor, &c.

Trail Cars.—There are five trail cars of the two-axle type—two to carry each 55 passengers, two to carry each 40 passengers, and one combination passenger, postal, and baggage car carrying 20 passengers.

Running.—As the cars are operated by three-phase, a practically constant speed of 36 km. per hour is maintained. The cars can be braked quickly and stop in about three-quarters of a minute; a table of tests made on the 2½ per cent. grade is given. Tests of the power consumption at starting gave the following results:—

(*a*) One motor and one trail car on 2½ per cent. grade straight track, 260 amperes at 760 volts.

(*b*) Same as above, but on curve 250 m. radius, 330 amperes at 850 volts.

(*c*) The maximum consumption of the electric locomotive with a complete train of 50 tons at 36 km. per hour never exceeded 300 amperes at 700 volts.

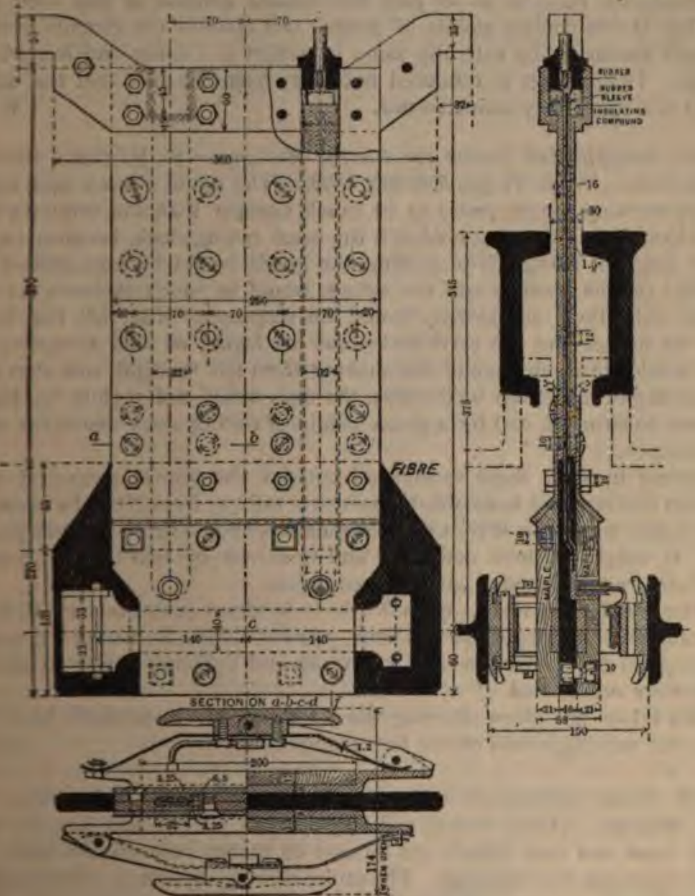
It has been found not advisable to run two trains of cars at the same time in a section fed by one transformer. With two trains they should be six minutes apart, and with three trains the headway is ten minutes. (The article is abundantly illustrated.) E. K. S.

766. *Electric Conduit Construction in Paris.* **A. N. Connett.** (Street Rly. Journ. 15. pp. 845–852, Dec., 1899.)—In some of the larger French cities the trolley is forbidden in certain streets, and conduit lines have been laid down. In Paris the Bastille-Charenton line has a short section of conduit with the central slot somewhat similar to the Metropolitan Railroad Company of Washington, except that the cast-iron insulator shields are bolted directly to the bottom flange of the slot rail. The insulator pits are also covered with cast-iron plates, placed low enough to allow of being paved over, this being necessary, as by the municipal regulations, manhole covers must be reduced to a very strict minimum.

In new lines which were projected, the most important being the "St. Ouen-Champ de Mars," the French Thomson-Houston Company made every effort to continue the construction of this central slot conduit, but were met with opposition from the authorities, and were therefore obliged to adopt the side-slot conduit. Compared with the centre this method has several disadvantages: (1) The question of slot closure becomes doubly important from the fact that the wheel flanges, as well as the plough shank, must pass into the slot. (2) The entire car traffic passing on the overhung yoke seats makes a stronger construction necessary. (3) The plough insulation is rendered more difficult from the splash of mud and water directly on it from the wheels. (4) It is fundamentally impossible to make a really satisfactory side-slot switch.

In Paris the last difficulty has been avoided by the device of deflecting the slot from the side to the centre at such points (Avenue Marceau), when switches are absolutely necessary,

On some lines the plough has been so constructed that it will pass through the normal slot, but this is after all of slight practical value. In Paris the author decided not to adopt this method, but to make the plough thoroughly mechanical and of high insulation resistance, arranging for its withdrawal at certain points. The withdrawal is effected through cast-steel doors in the slot, which can be raised and lowered by a removable lever carried on the car, or, where traffic is heavy, attended to by a man set apart for the purpose.



(Good illustrations are given of the conduit and of the trap-door arrangement. The drawing of the plough is here reproduced.)

The conduit walls are of concrete, made to shape by sheet-iron formers, which are afterwards withdrawn through the slot. Being in three separate parts this withdrawal is quite easy.

At one point the line crosses the Seine by the Pont Alma, and as the height of the masonry arches would not permit of the regular conduit, a specially shallow one had to be designed. It consists of a continuous cast-iron U-tube, nearly covered in by steel plates, upon which special **Z** bars are bolted to form the slot. This construction necessitates the raising of the

therefore to be made to raise and lower the plough when going over the bridge.

The design of the plough support was difficult, because the conditions to be fulfilled were : (1) That the plough should be able to slide laterally the full width of the track. (2) That at its central position it could be raised clear from the conduit so as to be carried over the trolley section, and, *vice versâ*, to be lowered into the conduit. (3) That it could be raised and lowered from each of its side positions the necessary distance between the height of the conductor rails, so as to pass the shallow conduit of the Pont Alma. (4) That at the contact points of trolley and conduit the circuits could be changed automatically with the same operation of raising and lowering the plough. This change is rendered necessary from the fact that the conduit circuit is a completely insulated one. E. K. S.

767. *Multiple Unit System for Electric Railways.* **F. Křižik.** (Zeitschr. Elektrotechn., Wien. 17. pp. 555–560, 1899.)—The use of electric unit cars for railway working should prove to be much cheaper than the ordinary heavy steam locomotive dragging behind it the usual rolling stock, because (*a*) each motor waggon, being self-propelling, the goods would be transported more quickly ; (*b*) the stations and the sidings would be much shorter ; (*c*) water basins, with their accessories, would be dispensed with ; (*d*) the bridges could be lighter and the earthworks and the laying of rails cheaper ; (*e*) as there would be an absence of the shaking from left to right, and also of the hammering of the steam locomotive, the rails would not require to be held together so strongly, and for a given weight of rolling stock could be lighter and cheaper.

Having in view these various advantages the author proposed to the Austrian Government to establish an electric railway from Nusle to Mechenic. Each motor waggon is driven by accumulators, and so forms an independent unit. It weighs 12 tons complete, and is driven by two 35 H.P. motors; 280 Tudor cells in wooden cases are employed.

After satisfactory results from Nusle to Modram (a distance of 12·3 km.), with only one charging there and back, another station farther in the country at Konigsaal was chosen, where an engine and dynamo similar to those at Nusle were established.

Two tables are given showing the results of the tests which have been made, but nothing is said on the financial question. E. K. S.

768. *Racing Automobile by the Columbia Company.* **J. B. Entz** and **H. P. Maxim.** (Elect. World and Engineer, 34. pp. 967–969, Dec. 23, 1899.) —The front and rear wheels are 32 and 36 inches respectively, with solid rubber tyres and ball bearings. The entire driving system is suspended in a self-contained case, or "torpedo," which is pivoted on the rear axle, and includes motor, pinions, balance gear, and all bearings. The forty-eight all-lead accumulators weigh 980 lbs., the carriage ready for them 1,200 lbs., the capacity is 124 ampere hours at 22 ampere discharge. One hundred miles were covered at an average of 12·9 miles per hour for 13·6 kw. hours expended. A further 50 miles was then run after recharge at an average of 20 miles pe hour. M. O'C

769. *Kriéger Electric Car.* **J. Reyval.** (Écl. Électr. 21. pp. 481–48 Dec. 30, 1899.)—The author describes the general construction and design *the latest* models, as well as of previous forms. The unusual feature of the

cars is that separate motors drive each of the front steering wheels; no differential gear is in consequence used. A device for steering by means of varying the two motor speeds is described, but has been abandoned. Speed regulation is effected, primarily, by changing from series connection of accumulators to the two halves of battery in parallel, and, secondarily, by varying the motor (field and armature) connections. Eight speeds are provided, giving from 4 km. per hour to 25; diagrams of connections are given. Fulmen accumulators are used, 44 cells, B 17 type, weighing 10·4 kgs. each. The total weight of vehicle (Victoria) with battery is 1,840 kgs. The car is said to run 80 km. on one charge, at an average speed of 18 km. per hour. The four-pole motors weigh 65 kgs. each; they are 3 kw. machines working at 2,500 revolutions per minute, and have an efficiency (maximum) of 87 per cent. Helicoidal gearing, with a ratio of 16·5 to 1 speed reduction, transmits the energy to the driving wheels, and the efficiency of motor and gearing is given as 82 per cent. No particulars as to either the efficiency or the depreciation of the accumulators are given. A. G. N.

770. *Method of Testing Rail Joints.* (Street Rly. Rev. 9. p. 812, Nov. 15, 1899.)—The Chase-Shawmut Co., of Boston, Mass., have introduced a device for testing joint resistance. It consists of three pole-spears, wired to a case containing a continuous interrupter and a telephone attachment. An assistant strikes two of the poles into the rails about 18 inches on either side of the joint, and the operator strikes the third pole into the rail about 4 feet from either of the other poles. By means of a switch the operator alternately throws the telephone and interrupter into the circuit containing the joint and the 4 feet of rail. He then adjusts the distance apart of the poles until the noises from both circuits are nearly equal, getting a fine adjustment by balancing one circuit against the other, when no sound at all should be heard if their resistances are equal. The ordinary return circuit in the rail is used. E. H. C.-H.

771. *Electrolysis of Water Mains.* L. I. **Blake.** (Elect. World and Engineer, 34. pp. 934–935, Dec. 16, 1899.)—Owing to the greater resistance of the joints compared to the pipe itself, water mains cannot be regarded as uniform conductors. If connected to the return of an electric tramway a portion of the current is shunted at the joint by the water inside and outside the pipe, causing electrolytic corrosion. Numerous tests of pipe lengths are given, showing that from 80 to 90 per cent. of the resistance occurs in the joints, the pipes being pitted inside and outside on the positive side of the joint to a depth in some cases of ¼ inch. L. B.

772. *Merriman's Contact System.* (Elect. Engin. 24. pp. 467–468, 1899.) —A mechanical contact system. The car wheels depress the short arm of a lever whose other end (heavily weighted to prevent lighter weights moving the lever) brings a contact-pin to the surface plate. E. H. C.-H.

773. *Track Construction Used in Scranton, Pa.* (Street Rly. Rev. 9. pp. 744–746, Nov. 15, 1899. Paper read before the Pennsylvania Street Rly. Association, Oct. 11–12, 1899.)—A light, 57-lb. T-rail has been used, strengthened at the joints by an inverted 4-feet length of the same rail, placed under the joint and secured by eighteen ¾-inch rivets driven by a portable pneumatic riveter. Four of the rivets are copper and form bonds. Other inverted lengths of old T-rail are used as ties, riveted to the foot of the rail every 10 feet; this in

addition to ordinary tie rods at 10-feet centres. The rails rest on 6 inches of concrete, and the paving is vitrified brick with a special shaped brick next the rail fitting into the web and having a groove for the wheel flanges.

E. H. C.-H.

774. *Recuperation of Accumulators on Vehicles.* **P. Bunet.** (Ind. Élect. 8. pp. 464–467, 1899.)—Sarcia, in 1895, published the results of experiments on the Paris accumulator tramways, which conclusively proved that on descents a considerable portion (from 28 to 42 per cent.) of the energy expended in ascending could be returned to the battery. The author shows that the reason why this result has not been utilised on tramways is that it involves the use of a shunt motor, which takes more current to give the same torque than a series motor, and which consequently loses in efficiency uphill more than it gains by recuperating the cells on a down gradient. A shunt motor under these conditions will require a higher discharge-rate from the battery: it will also spark. On the other hand, the sparking at the controller contacts will be less with a shunt motor, because the armature circuit is never completely broken on account of the fields. Starting torque may be increased by compound winding, but this complicates the connections for recuperation. For automobiles the conditions are different, because there are fewer stops and it is more frequently necessary to go slowly.

E. H. C.-H.

775. *Magnetic Observatories and Trolley Wires.* **S. Wächter.** (Elektrotechn. Ztschr. 20. pp. 655–657, 1899.)—A description of the double trolley line adopted in Strassburg to prevent magnetic disturbances due to traction currents. The forward and return conductors are placed 80 cms. apart, and are supported by a compound insulator whose constituent parts are connected by a rod of insulating material. The cars are provided with double trolley poles. The arrangement is said to work satisfactorily. A. H.

776. *Illuminating Power of the Alternating Arc.* **A. Blondel and Jigouso.** (Écl. Électr. 21. pp. 141–142, 1899. Paper read before the Assoc. française, Boulogne.)—The illuminating power of the alternating arc depends to an enormous extent upon the nature and diameter of the carbons, on the density of the current, and on the length of the arc. These details must be kept in view in comparing different arcs. Increasing the frequency of the alternations is not necessarily a benefit; the carbons must be selected with a view to the actual frequency employed. Large arcs have much higher efficiency than small ones, but within limits thinner carbons are better. The duty is much higher if the curve of the current (not of the E.M.F.) be made rectangular; but there is as yet no applicable method of doing this on a commercial scale. The total luminous flux is from 20 to 40 per cent. less with alternating currents than that corresponding to the same amount of energy with continuous currents; the amount of difference depends greatly on the kind of carbons and on the voltage under which they are used.

A. D.

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777. *Arc Lamps.* **G. Richard.** (Écl. Électr. 21. pp. 16–24, 1899. Read before the Association Française pour l'avancement des Sciences.)—Descriptions of arc lamps of Bergmann, Thomson, Houston, Lewis, Johnson and Wunderlich, Sandy, Brown, Vassier, Stralsund, Mersch, Oliver, Pomeroy, Arter, Ischieret, Willman, and Lamp de la Company de l'Industrie Électrique. (See 1899, Abstracts Nos. 958, 1449.)

778. *"Belden" Arc Lamp.* (Elect. World and Engineer, 34. pp. 869–870, Dec. 2, 1899.)—Description of the Belden Enclosed Lamp.

779. *Swiss Engineering.* **E. K. Scott.** (Lightning, 16. pp. 375 and 380, 1899.)

780. *Warsaw Central Station.* (Elect. World and Engineer, 34. pp. 690–692, Nov. 4 ; 735–737, Nov. 11 ; 775–778, Nov. 18 ; 856–858, Dec. 2 ; 896–898, Dec. 9, 1899.)—1. Report by W. H. Lindley. 2. Description of generating station. 3. Arrangement of circuits. 4. Transformers. 5. The Street Railway System.

781. *Hereford Electricity Works.* (Elect. Engin. 24, pp. 750–757, Dec. 15, and 782–783, Dec. 22, 1899.)

782. *New Tramcar.* (Electrician, 44. p. 255, Dec. 15, 1899.)—Illustrated description of a tramcar for the Dublin United Tramways Company.

783. *Electrical Quarry-Installation.* (Elect. Rev. 45. pp. 1007–1010, Dec. 22, 1899.)—Description of an electrical transmission of power plant near Dumfries.

J. T. R.

784. *Aluminium Conductors.* (Ind. Elect. 8. pp. 512–513, Nov. 25, 1899.)—Describes briefly sizes and arrangement of the aluminium conductors at the Snoqualmie and Blue Lakes installations. (See also 1899, Abstract No. 516.)

785. *Automobiles on Hire.* **S. C. Crane.** (Elect. World and Engineer, 34. pp. 927–931, Dec. 16, 1899.)—Management details, and a method of removing accumulators by a truck with turntable are given, as well as efficiency, torque, and speed curves of the Eddy motor. M. O'G.

786. *Overhead Line Construction.* **A. B. Herrick.** (Street Rly. Journ. 15. pp. 865–867, Dec. 1899.)—Notes on the installation and testing of feeders, and the erection of poles.

787. *Electric Railway Practice in Germany.* **L. J. Magee.** (Street Rly. Journ. 15. pp. 647–662, 1899.)—A review of the existing electric traction work in Germany, with tables of financial results, illustrations of power houses, motors, track construction, rolling stock, &c. E. H. C.-H.

788. *Electric Railway Practice in Great Britain.* **S. H. Short.** (Street Rly. Journ. 15. pp. 663–673, 1899.)—A review of British traction work, on the same lines as the article referred to in the previous reference. E. H. C.-H.

789 *Electric Railway Practice in Austria-Hungary.* **E. A. Ziffer.** (Street Rly. Journ. 1. pp. 685–692, 1899.)—An outline of the general practice in the construction and equipment of the 240 miles of electric railways in these countries.

E. H. C.-H.

790. *Track Construction in German Cities.* **H. Géron.** (Street Rly. Journ. 16. p. 49–51, Jan., 1900. Paper read before the Elberfeld meeting of the Verein [illegible]scher Strassen- und Kleinbahn Verwaltung.)—The author gives the opinions of [illegible]mber of companies as to different kinds of rails, rail joints, and track construc[illegible] for electric cars, and conclusions thereon from experience. Several kinds of [illegible]

TELEGRAPHY AND TELEPHONY.

791. *Wireless Telegraphy at High Altitudes.* **J.** and **L. Lecarme.** (Comptes Rendus, 129. pp. 589–591, 1899.)—Between Mont Blanc (4,350 m. high) and Chamonix (1,000 m.), a distance of 12 km., signalling was uninterrupted by cloud or thunderstorm, although the land surface was free from water in the liquid state. The starting of the 3-phase electric light station at Chamonix entirely stopped possibility of communication. M. O'G.

792. *"Automatic" Telephone Call-Box.* (Electrician, 44. pp. 181–182, Dec. 1, 1899.)—Telephones on the "penny-in-the-slot" principle are largely used in Copenhagen. The inventor of the devices here described is L. M. Ericsson, of Stockholm. A coin of the value of 10 öre (about 1¼d.) is required to operate the calling arrangement. It falls between two forks, which are normally insulated from each other, and makes connection, across the forks, to the exchange. Should the operator give connection to the subscriber wanted and announce the fact, the caller presses one of two buttons, when the coin falls within the case against a gong, to which the microphone is attached, and this is heard by the exchange operator. If, on the other hand, the subscriber wanted is engaged, the caller is thus informed, and, upon pressing the second of the two buttons upon the exterior of the case, the coin is restored by descending a vertical flat tube. Telegrams can be telephoned to the exchange, the operator there informing the caller of the amount to be paid. The necessary coins are then dropped through two slots at the right-hand top corner of the instrument; on their way they strike against gongs, by means of which the operator is acquainted with the amount paid in. About 465 of these instruments are in use. E. O. W.

793. *Telephone Conduit.* **E. Piérard.** (Électricien, 18. pp. 318–31[illegible] Nov. 11, 1899.)—In Brussels a layer of slow-setting cement 10 cm. thick [illegible] made the bed for glazed pottery tubes. The cement consists of a mixture [illegible] calcium carbonate and clay, containing at least 20 per cent of magnesia, an[illegible] made at least three months before use. The earthenware pipes, 8·4 cm. diam[illegible] 46 cm. long, which have an oblique joint, are laid in the bed and cemented [illegible] with cement mortar, containing 550 kg. cement per meter cube of sand. Th[illegible] whole is then covered in with cement to a depth of 10 cm. Manholes a[illegible] used; 400 metres is the length of a run. M. O'G.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

APRIL 1900.

GENERAL PHYSICS.

794. *Elasticity of Cast Iron.* **P. A. Thomas.** (Ann. d. Physik, 1. 2. pp. 232–243, Feb., 1900.)—This is a criticism of the methods hitherto adopted for determining the elastic coefficients of iron at various temperatures. The author discusses the sources of error, and points out that temperature has an effect which depends upon the duration of exposure to it. E. E. F.

795. *Elasticity of Wires.* **G. F. C. Searle.** (Phil. Mag. 49. pp. 193–199, Feb., 1900.)—To the ends of a wire are attached parallel rods which are at right angles to the length of the wire. If the wire executes a transverse vibration in the plane of the rods, it is clear that the period depends on the inertia of the various parts (especially of the rods) and on the resistance to bending, which can be calculated from Young's Modulus, and the dimensions of the wire. To the middle of each rod is attached a light hook, the stem of which is at right angles to the plane of the rods. The system is suspended by two strings, one attached to each hook, the plane of the rods being horizontal. If the strings are long enough, the vibration of the system is practically free. Thus the period of the ideal vibration can be approximately determined, and Young's Modulus can be calculated with the aid of the formulæ developed in the paper. To determine the Modulus of Rigidity, one of the rods is clamped in a horizontal position to a suitable support, in such a manner that the wire hangs vertically downwards. The time of vibration of the rod at the bottom, about the axis of the wire, is then determined, and the Modulus is calculated in the usual way.

A table is given showing the results obtained with various wires. In certain cases the relation between the Moduli is such that Poisson's ratio, calculated from the well-known equation, is apparently greater than 0·5. As this, if rect, would imply a negative bulk-modulus, or an increase of volume with rease of hydrostatic pressure, the author infers that the wires in question e so far from being isotropic that it is improper to apply the theory of ropic solids to them." A. G.

796. ***Froth of Soap Solutions.*** **D. H. Hall.** (Roy. Dublin Soc., Proc. 9. [illegible]-59, 1899.)—It is proved experimentally that the liquor derived from the

soap than the original solution. There must, therefore, be a concentration of the soapy matter after the formation of a film. The author points out that this agrees with a suggestion by Rayleigh, made in connection with the explanation of the stability of soap-bubbles and of the foam of frothing liquids.

A. G.

797. *Diffusion of Gases.* **M. Brillouin.** (Annal. Chim. Phys. 18. pp. 433–448, 1899.)—This paper is mathematical and treats of the theory of the diffusion of gases in the absence of porous partitions. It is shown that, in general, diffusion must be taken into account when the transmission of sound (with its condensations and rarefactions) takes place through a gaseous mixture. This diffusion causes variations in composition of the mixture, which are comparatively great when the densities of the gases forming the mixture are very dissimilar.

A. G.

798. *Directive Action of one Crystal on another.* **J. H. Poynting and P. L. Gray.** (Roy. Soc., Phil. Trans. 192. pp. 245–256, 1899.)—An account of these experiments has already been published in the Roy. Soc. Proc. (See 1899, Abstract No. 777.) In the present paper a full account is given of the apparatus used and the methods of observation, also of the equations of motion. On the assumed law of force the result implies that the attraction between the two spheres, with distance 5·9 cm. between their centres, do not differ in the parallel and crossed positions by as much as $\frac{1}{16500}$ of the whole attraction. The result found for the semicircular couple implies that the attractions between the two spheres with 5·9 cm. between their centres, with their axes parallel and respectively in like and unlike directions, do not differ by as much as $\frac{1}{1650}$ of the whole attraction.

This limit is large, owing to the want of axial symmetry in the apparatus which produced a semicircular couple. This couple was large, and though the authors attempted to eliminate it by two sets of observations with different azimuths of the larger sphere, they consider that in all probability they failed.

J. J.

799. *On a Theorem of Clebsch's.* **P. Saurel.** (Phys. Rev. 9. pp. 300–[illegible], 1899.)—Clebsch's theorem is that every solution of the equations of motion of a vibrating elastic solid can be written in the form—

$$u = \frac{dP}{dx} + \frac{dW}{dy} - \frac{dV}{dz}$$
$$v = \frac{dP}{dy} + \frac{dU}{dz} - \frac{dW}{dx}$$
$$w = \frac{dP}{dz} + \frac{dV}{dx} - \frac{dU}{dy}$$

U, V, W, being three solutions of the equation $\frac{d^2\phi}{dt^2} = a^2\Delta\phi$,

and P being a solution of both the equations $\frac{d^2P}{dt^2} = b^2\Delta P$ and—

$$\Delta P = \frac{du}{dx} + \frac{dv}{dy} + \frac{dw}{dz}$$

where u, v, w, are the displacements. The present paper simplifies Cl[illegible] *demonstration.*

S.

[redacted]

800. *Hydrodynamics and Hertzian Mechanics.* **R. Reiff.** (Ann. d. Physik, 1. 2. pp. 225–231, Feb., 1900.)—Hertz's system of mechanics is defined by the principle that the forces acting upon a system are to be replaced by the coupling of this system with a second system in such a manner that the work performed by the first system is equal to the increase of kinetic energy in the second system. The author shows that in a continuously varying system, such as is presented by a perfect liquid, the method devised by Hertz encounters serious difficulties. In ordinary dynamics, the hydrodynamic pressure appears as the potential of the forces derived from the condition of the preservation of mass. The Hertzian proposal would dispense with this most fundamental and important condition, probably the most firmly established in physics.

E. E. F.

801. *Electrical Theory of Solar Corona.* **A. Souleyre.** (Revue Scientif. 4. pp. 622–627; and 652–657, 1899.)—This is a description (too lengthy to abstract in detail) of the probable connections existing between the variations in the phenomena of solar activity, planetary magnetic and geographical conditions, and interplanetary perturbations, based on the supposition that the electrical forces undoubtedly existent in the solar system constitute the determining factors. One possible cause of the electrification of the solar corona is stated to be the interaction of the currents produced in the sun's atmosphere by variations of temperature, in a similar manner to our terrestrial electrical phenomena, the kinetic energy of motion being partly changed into electrical energy. The varying forms of the coronal structure may be partly due to the constantly varying attractions of the other planets. After showing that the two chief factors in this action will be Jupiter and Saturn, data are given stating the degree of periodicity which would be expected from a consideration of the planetary movements. That produced by Jupiter is strikingly similar to the shorter of the two sun-spot cycles, viz., a little more than eleven years. Saturn would give rise to a periodicity of about twenty-seven years, which of itself is not represented in the solar phenomena as at present known. But if *two* of these twenty-seven yearly periods of Saturn are combined with *five* of the eleven yearly periods of Jupiter, it is evident that a long periodicity of about fifty-five years will result. This is closely in agreement with the *great* sun-spot cycle of fifty-five and a half years. The author then proceeds to sum up most of the known cases of terrestrial phenomena having a suspected periodicity of similar degree to the sun-spot cycles, giving in the course of it an excellent description of the *zones of interference* produced in the earth's atmosphere. Dealing with the magnetic atmospheric phenomena, he states that the maxima of aurora in *temperate* regions approximately coincide with the minima of auroræ in Arctic regions, and that it is likely the magnetic poles are in such motion as to complete a revolution in six hundred years. The second paper applies similar reasoning to the explanation of variations of latitude and the inequalities of the orbital motion of Mercury and the moon. C. P. B.

802. *Wave-Length of Corona Line.* **C. A. Young.** (Astrophys. Journ. 10. pp. 306–307, 1899.)—As the original author of the misidentification of the corona line with the chromospheric line 1,474 K (λ 5,317), Young replies to the note of Campbell in the October number, announcing the more accurate value. (See 1900, Abstract No. 456.) Young sees no ground to contest the conclusions of Lockyer and Campbell that the true value is near λ 5,303, the photographs obtained during the 1898 eclipse being quite satisfactory

evidence. The reason of the retention of the error was the uncertainty of the duration of totality at the eclipses of 1870 and 1878, leaving Young no time to complete his observations for comparison of the chromospheric and coronal lines. It is noteworthy that at the new wave-length of the corona line λ 5,303, there is no line of the solar spectrum, either dark or bright, nor, so far as is at present known, is there any line of any known terrestrial substance at this position. C. P. B.

803. *Great Sun-Spot, September, 1898.* **J. Fényi.** (Astrophys. Journ. 10. pp. 333–336, 1899.)—The article describes the phenomena observed during the period of visibility of this spot, one of the largest that has been seen on the solar surface. The widespread prevalence of auroræ and magnetic disturbances were specially noticeable. Spectroscopic determinations of the distortion of lines showed the matter in and surrounding the spot to have velocities as high as 470 km. per second. C. P. B.

804. *Solar Eclipse Problems.* **G. E. Hale.** (Astrophys. Journ. 11. pp. 47–66, Jan., 1900.)—The author gives a short summary of the most important branches of solar physics which it is advisable should receive attention at subsequent total eclipses. These include: (1) Naked-eye drawings of corona; (2) Drawings at the telescope; (3) Colour of corona and prominences; (4) Small scale photographs of corona; (5) Photographs of corona during partial phase before and after totality; (6) Photographic search for possible intra-mercurial planets; (7) Large-scale photographs of corona and prominences; (8) Distribution of *coronium*; (9) More accurate value for wave length of green corona line; (10) Photographs of spectrum of chromosphere; (11) Photographs of spectrum of corona; (12) Heat radiation of corona. C. P. B.

805. *Escape of Gases from Planetary Atmospheres.* **S. R. Cook.** (Astrophys. Journ. 11. pp. 36–43, Jan., 1900.)—The author extends the work of G. Johnstone Stoney (see Astro-Phys. Journ. 7. p. 25, Jan., 1898; Trans. Roy. Dublin Soc. vi. part 13), by determining, with the aid of the kinetic theory, the relative number of molecules which would have a velocity sufficient to enable them to escape from the earth or planet, assuming there be no retarding media. This velocity he designates the *critical velocity* of the gas. The result indicates that the amount by which the various planetary atmospheres are being diminished is exceedingly small. The conditions have been computed under four different sets of assumptions, based on the observations of Stoney, Cleveland Abbe, and Ferrel. C. P. B.

806. *Earthquake of Balikesri* (*Asia M.*) *of September* 14, 1896. **G. Agamennone.** (Accad. Lincei Atti, 8 pp. 365–368, 1899.)—Balikesri is the only place known where the earthquake did any damage, the intensity being 7–8°, on the scale De Rossi-Forel. It is very probable that the epicentre was somewhere about this locality, the latitude being 40° N. and the longitude 28° E. of Greenwich. The author points out that there appear to have been tw seismic waves. By comparing the indications of the instruments at Padı and Nicolayef with those at Constantinople he determines the velocity of tl more rapid waves to be about 8¼ kilometres per second. The rapid wav are probably longitudinal. The slower waves are probably transversal, aı are due to the surface of the earth moving up and down in a mode analogo to the waves of the sea; the velocity of their maximum phase is ab 2¼ kilometres per second. A.

807. *Roman Earthquake of July* 19, 1899. **P. Tacchini.** (Accad. Lincei Atti, 8. pp. 291–296, 1899.)—The principal shock at Rome was of intensity VII.–VIII., on the scale De Rossi-Forel. According to Cancani the epicentre was near Frascati, Grottaferrata, and Marino.

The table given below indicates the velocity of the leading seismic waves.

Distance from epicentre.	Place.	Time of beginning (t.m.C.E.).			Apparent velocity per second.
		h.	m.	s.	
20 km.	Rome	14	18	55±3	...
160 „	Ischia	14	19	37	3·33 km.
170 „	Portici (Naples)	14	19	21	5·00 „
250 „	Quarto (Florence)	14	19	26±2	7·42 „
400 „	Padua	14	20	7	5·28 „
490 „	Lubiana (Carniola)	14	21	58	2·57 „
520 „	Catania	14	21	2	3·94 „

It is pointed out that the differences can be partly attributed to the unequal sensibilities of the instruments. If the assumption be made that some of the instruments were too coarse to indicate the leading waves, the following slightly different values for the velocity are obtained: 4·00 (Ischia), 8·82 (Portici), 9·58 (Quarto), 5·85 (Padua), 2·67 (Lubiana), 4·17 (Catania).

So far as is known there were no preliminary shocks, and no precursory phenomena. A. G.

808. *Earthquake in Emilia, March* 4–5, 1899. **G. Agamennone.** (Accad. Lincei Atti, 8. pp. 321–326, 1899.)—The epicentre was at lat. N. $44\frac{1}{2}$°, long. $10\frac{1}{2}$° E. of Greenwich. The maximum intensity was VIII. on the scale De Rossi-Forel. The author mentions the difficulty of obtaining reliable data for determinations of the velocity of the seismic waves; applying the method of least squares, he obtains a mean value of 2,900 metres per second. It is of interest to compare this mean with the values determined from limited data, more or less reliable. The velocity from Padua to Rome comes out to be 2,600 metres per second, from Florence to Rome 4,100 metres per second. The first value is perhaps too small, because the instrument at Rome was less sensitive than that at Padua; whilst the second value is perhaps too high, because the instrument at Rome was more sensitive than that at Florence. A calculation of the velocity of maximum phase would lead to results still more erratic. A. G.

LIGHT.

809. *Refractive and Magnetic Rotatory Powers of Aromatic Hydrocarbons and Refractive Powers of Mixtures.* **W. H. Perkin.** (Chem. Soc., Proc. 15. pp. 237–238. Discussion, p. 238, 1899.)—The author's results lead to the following conclusions: Replacement of a hydrogen atom by a methyl group gives a larger value for the refractive power when the replacement occurs in the nucleus than when it takes place outside. In the latter case the results are higher than the calculated, but the difference tends to vanish as the distance of the substituent group from the nucleus increases. With the magnetic rotation, on the other hand, a change in composition of CH_2 produces a smaller increase when in the nucleus than when outside it. These results hold for 4 and probably for the whole 6 replacements. Measurements of the refractive powers of various mixtures of fatty as well as aromatic compounds show that when the two constituents of a mixture have very widely different indices of refraction the specific or molecular refraction is considerably lower than the calculated value, but that when the separate indices are nearly equal the calculated and experimental numbers show good agreement. T. H. P.

810. *Great Refracting Telescope, Paris,* 1900. (Scientific American, 81. pp. 298–299, 1899.)—This is an interesting description of the large refractor being constructed by Gautier for the Paris Exhibition of 1900. Full details are given of the apparatus for substituting either a visual or photographic lens. The objectives are 4·1 feet in diameter, with a focal length of about 197 feet. These are fed with light from the celestial bodies by means of a siderostat, the mirror of which is 6·56 feet in diameter. On account of the uncertain weather in Paris it is probable that the instrument will be set up at some distance from the city. C. P. B.

811. *Calibration of Slit in Spectro-photometry.* **E. V. Capps.** (Astrophys. Journ. 11. pp. 25–35, Jan., 1900.)—This article deals first with the description of the intensity curve of the spectrum, proceeding to describe the new spectro-photometer designed by G. B. Brace, of Nebraska University, with which the work has been performed. Great difficulty was found in obtaining a source of light which should at once be constant, uniform, and of great intensity. The form finally adopted was a specially made incandescent lamp, having a flat filament about 12 mm. wide, which was placed about 12 cm. from the slit. The artificial variation of one of the sources of light was obtained by a notched rotating sector, the proportions of which were such that the intensity was diminished one-eighth of the whole for every advance of one notch. Curves and tables are given of the settings obtained, showi[ng] that in the case of a crown glass prism the intensity increases faster than t[he] width of the slit in the red and blue, but slower in the yellow. Using a fl[int] glass prism the general result is the same, but not so pronounced in degr[ee]. From the experiments the following conclusions may be drawn :—

(1) The direct-ratio law holds for only two points in the spectr[um] corresponding approximately to wave-lengths λ 6,200 and λ 5,700. (2) [The] variation is greatest in the red and blue regions of the spectrum, and [...]

and of opposite sign in the yellow. (3) It increases as the slit increases in width. (4) It decreases as the refractive power is increased. (5) It is practically independent of the relation of the two light sources provided they do not differ by more than 50 per cent. in intensity. C. P. B.

812. *Colour Sensations in Terms of Luminosity.* **W. de W. Abney.** (Roy. Soc., Proc. 65. pp. 282–283, 1899; and Roy. Soc., Phil. Trans. 193. pp. 259–287, 1899.)—This paper deals with a determination of the colour sensations based on the Young theory by means of measures of the luminosity of the three different colour components in a mixed light which matches white. At the red end of the spectrum there is only one colour extending to near C, and there is no mixture of other colours which will match it, however selected. At the violet end of the spectrum, from the extreme violet to near G, the same homogeneity of light exists, but it is apparently due to the stimulation of the two sensations, a red and a blue sensation, the latter never being felt unmixed with any other. By trial it was found that close to the blue lithium line the blue sensation was to be found unmixed with any other sensation except white. The complementary colour to the red in the spectrum gave a position in which the green and blue sensations were present in the right proportions to make white, and a point nearer the red gave a point in which the red and blue sensations were present in such proportions as found in white, but there was an excess of green sensation. The red, blue, and green sensations were thus located. The position in the spectrum of the yellow colour complementary to the violet was also found. The colour of bichromate of potash was matched by using a pure red and the last-named green. To make the match, white had to be added to bichromate colour. A certain small percentage of white was found to exist in the light transmitted through a bichromate solution with which the match was made, and this percentage and the added white being deducted from the green used gave the luminosity of the pure green sensation existing in the spectrum colour which matched the bichromate. Knowing the percentage composition in luminosity of the two sensations at this point, the luminosity of the three sensations in white was determined by matching the bichromate colour with the yellow (complementary to the violet) and the pure red colour sensation. From this equation and from the sensation equation of the bichromate colour already found, the composition of the yellow was determined. By matching white with a mixture of the yellow and the violet, the sensation equation to white was determined. The other colours of the spectrum were then used in forming white, and from their luminosity equations their percentage compositions in sensations were calculated. The results found from the percentage curves were applied to various spectrum luminosity curves and the sensation curves obtained. Attention is called to the results deduced from these curves and from other curves obtained from them, and the difference between Koenig's determination and that of the author is pointed out. J. J. S.

813. *Instantaneous Photography.* **G. Sigriste.** (Comptes Rendus, 130. pp. 82–84, Jan. 8, 1900.)—The shutters used for instantaneous exposure are of two types. Those attached to the lens produce an even increase and decrease of the illumination over the whole picture, but their efficiency is low, and they give rise to diffraction phenomena when the exposure is very short. The only thoroughly scientific shutter is the second type, consisting of a slit moving rapidly across the sensitive plate itself. The transition between darkness and exposure is instantaneous, and hence the efficiency is a maximum.

But for a good result the interval between the shutter and the plate must be not over 0·1 mm., and the edges of the slit must be sharp and carefully bevelled so as to exclude disturbance by reflection. E. E. F.

814. *Photographic Image in Stratified State.* **A. Trillat.** (Comptes Rendus, 130. pp. 170–172, Jan. 22, 1900.)—The author has succeeded in depositing the amorphous silver of a photographic image in a stratified state.

The plate is polished and hardened and exposed to the action of the vapour of nitric acid. This dissolves the silver, which remains in the gelatine in a colloidal condition. It is then precipitated by exposure of the plate to a stream of sulphuretted hydrogen, and assumes a stratified form, showing iridescent colours. There is no relation apparent between the colours obtained and the real colours of the object photographed, but the colours seem to vary with the thickness of the silver deposit, and the author was able to artificially localise colours corresponding to the actual colours. G. H. B.

815. *Law of Reciprocity for Bromide of Silver Gelatine.* **K. Schwarzschild.** (Astrophys. Journ. 11. pp. 89–99, Jan., 1900; Photographische Correspondenz, 1899.)—The law of reciprocity states that the degree of blackening is the same when the product of the intensity of the light, I, and the time of exposure, *t*, is constant. Abney and others have found deviations from this law, and the author's experiments confirm these. He obtains the formula $I \times t^{0.86} =$ constant for constant blackening, employing Schleussner's plates, and varying the exposures from 8 to 5,000 seconds and the intensity of light from one to a thousandfold.

If the exposure, instead of being continuous, is interrupted, the total time of exposure remaining however the same, the resulting blackening is diminished. In the experiments, which are fully described in the paper, the exposure was made through a rotating disc with one or more slits, and each exposure was interrupted a considerable number of times. The diminution of blackening due to intermittence depends on two quantities; it increases with the ratio of the time of interruption to that of exposure, and it increases as the quantity of light reaching the plate during each single exposure diminishes. If this quantity exceeds what the author terms its limiting value, *i.e.*, a value which of itself produces a barely appreciable blackening, the effect of the intermittence is inappreciable, whatever the total length of exposure or the intensity of the light, but below the limiting value the smaller the quantity of light the greater is the effect of the intermittence. In one case, when the time of interruption was twenty-three times as long as that of exposure, the diminution of blackening amounted to 40 per cent., but when the times were equal the effect was very small. No appreciable influence is due to the degree of blackening and total length of the exposure, or to the luminous intensity. G. H. B.

816. *Decomposition of Luminous Vibrations.* **C. Fabry.** (Comptes Rendus, 130. pp. 238–241, Jan. 29, 1900.)—If

$$x = F(t)$$

be the law of a luminous vibration, the function F can, under certain conditions as to continuity, be represented by a Fourier integral,

$$F(t) = \int_0^\infty \phi(q) \sin 2\pi(qt - a)dq,$$

and we may then say that the movement represented by the first equation is the superposition of an infinity of pendular movements, the movement of frequency q having the amplitude $\phi(q)$ and the phase α. The distribution of energy in the spectrum will then be represented as a function of the frequency, by

$$W = [\phi(q)]^2.$$

H. Poincaré has raised the objection that the above integral represents the function F for all values of t, even for periods after the extinction of the source. This sounds paradoxical, but it is nevertheless true, and a grating would continue to show a spectrum for an indefinitely long time after the source had been extinguished if it were as perfect as the theory demands, *i.e.*, if the number of lines were infinite and its power of resolution were perfect. The infinite prolongation of the radiation would imply an infinite supply of energy, but this also is not surprising, since the incident wave-train would have to be of infinite extent. Thus the objection raised by Poincaré, while theoretically correct, fails to impair the practical usefulness of Gouy's theory.

E. E. F.

817. *Constitution of White Light.* **E. Carvallo.** (Comptes Rendus, 130. pp. 79–82, Jan. 8, 1900.)—The author throws doubt on the supposition that white light is due to a damped vibration. This is not in agreement with the observations of Morton and of Langley with regard to the distribution of intensity in the spectrum. If white light were due to a damped vibration of the type $e^{-kt} \sin ht$, the grating spectrum would not give different colours but white light over its whole area. The fault of the accepted theory lies in its neglect of the intensities of radiation, which in isolated regions are insensible to the eye, but which become of notable proportions when the formation of a Fourier series is in question. E. E. F.

818. *White Light and Röntgen Rays.* **E. Carvallo.** (Comptes Rendus, 130. pp. 130–132, Jan. 15, 1900.)—The effectiveness of gratings in giving to each colour a definite and constant intensity for any given source of light, without the various radiations interfering with each other, owing to the coherent differences of phase implied in Fourier's formulæ, points out the independence, and, so to speak, the individuality of each radiation. If, for instance, the two D lines of sodium arise from the decomposition of a single movement of invariable form, they must have the same difference of phase at the beginning of each disturbance. In that case they will produce beats by their interference. If, on the other hand, they are due to two vibrations which have an independent origin, no regular link will exist between the phases of the two components. The decision of this question by experiment appears very difficult, but with the aid of a revolving mirror it might be possible in the case of two lines much closer together. The author inclines to the belief that Röntgen rays are due to a non-periodic disturbance. This belief is confirmed by the absence of refraction and diffraction, for the author has previously shown that the front of every disturbance in the ether is propagated in any medium with the velocity of light in space, but that the disturbance is deformed in the course of its propagation. Even in periodic disturbances this is the case, but for these the periodicity is re-established in every point at the end of a certain time after the wave-front has passed the point. Hence the apparent slowness of propagation and refraction. These phenomena are due solely to periodicity, and Röntgen rays do not exhibit

refraction on account of their lack of periodicity. Hence their nature—that is, the form of the disturbance—must be modified as they penetrate growth into bodies, and the varying character of the secondary radiation studied by Sagnac is accounted for. E. E. F.

819. *Constitution of White Light.* **Gouy.** (Comptes Rendus, 130. pp. 241–244, Jan. 29, 1900.)—The author criticises Carvallo's objections to regarding white light as composed of damped oscillations. (See the two preceding Abstracts.) The simple oscillations which together are supposed to make up white light are purely fictitious, but they enable us to calculate the total energy spent between two given epochs. Carvallo's contention that if white light were composed of damped oscillations of the type $\epsilon^{-kt} \sin ht$, a grating would only yield white light from a white source, is vitiated by the fact that it involves an integration over the whole of time, which does not enter into practical physics. Damped oscillations form a workable hypothesis, but not the only possible hypothesis. E. E. F.

820. *Optical Problems.* **C. Godfrey.** (Roy. Soc., Proc. 65. pp. 818–819, 1899.)—The author points out that the solution usually given of the differential equation which governs the propagation of plane polarised light is applicable only to a train of waves without beginning or end, whereas in nature he says no radiation has this property. He suggests a solution by means of Fourier's integrals, thus—

$$f(t) = \int_0^\infty (\mathrm{C} \cos ut + \mathrm{S} \sin ut)\, du,$$

where—

$$\mathrm{C} = \frac{1}{\pi} \int_{-\infty}^{\infty} f(v) \cos uv\, dv,$$

$$\mathrm{S} = \frac{1}{\pi} \int_{-\infty}^{\infty} f(v) \sin uv\, dv,$$

so that $f(t)$ is the sum of simple circular functions of time. It is proved that this process is legitimate when $f(t)$ is such a function of time as occurs in physical problems. The method is applied to various cases of radiation. S. H. B.

821. *Magneto-Optic Rotation.* **J. Larmor.** (Cambridge Phil. Soc., Proc. 10. pp. 181–182, 1899.)—When in a material molecule there exists an independently vibrating group of ions or electrons, for all of which the ratio e/m of electric charge to inertia is the same, then the influence of a magnetic field H on the motions of this group is precisely the same as that of a rotation with angular velocity ω, equal to $\frac{1}{2}e\mathrm{H}/m\mathrm{C}^2$, imposed on the group around the axis of the field, on the hypothesis that the extraneous forces acting on the ions are symmetrical with respect to this axis (Phil. Mag., Dec., 1897.) This result involves the main features of the Zeeman effect; it requires that the separations of the doublets representing the spectral lines arising from such a group must all be equal when measured in difference of frequency, or be inversely as the square of the wave-length in vacuum when measured in difference of wave-length, relation which Preston has recently found to obtain for the natural series lines in ordinary spectra.

The author here points out that it is possible to deduce the Faraday effect from the Zeeman effect by general reasoning as regards any medium in which the optical dispersion is mainly controlled by a series of absorption bands for which the Zeeman effect obeys the above law, without its being necessary to introduce any special dynamical hypothesis. For this law ensures that the effect of the magnetic field on the periods of the corresponding free vibrations of the molecules is the same as that of a bodily rotation, say with angular velocity ω, round its axis; while the complete circular polarisations of the Zeeman doublets, viewed in the direction of the axis, show that their states of vibration are symmetrical with respect to that axis. Thus, Ω being the angular velocity of the displacement vector in a train of circularly polarised waves traversing the medium along its axis, the state of synchronous vibration which it excites in the molecules will have exactly the same formal relation to this train when the magnetic field is off as it would have to a train with the very slightly different angular velocity $\Omega \pm \omega$ when the magnetic field is on, the sign being different according as the train is right-handed or left-handed. Now change of this angular velocity Ω means change of period of the light: thus the propagation of a circularly polarised wave-train, when the field is on, is identical with that of the same wave-train when the period is altered by its being carried round with angular velocity $\pm \omega$, and there is no influencing magnetic field. This last result has been employed by Becquerel as a single hypothesis from which to deduce quantitatively both the Zeeman effect and the Faraday effect, and thus correlate them. (See 1898, Abstract No. 115.)

The preceding argument forms a general dynamical justification of this hypothesis for the case of all media in which the ordinary gradient of dispersion is mainly controlled by one or more powerful absorption bands beyond the visible spectra, for which the Zeeman constants are the same; it also shows that Becquerel's hypothesis has an approximate validity when these constants are nearly the same for all the effective bands. In the immediate neighbourhood of any single band the dispersion is anomalous, and is controlled practically by that band alone: the application will then be exact, and in Becquerel's hands it has given a complete account of the excessive and anomalous Faraday rotation first observed by Macaluso and Corbino in sodium vapour for light adjacent to the D lines. These simple general conclusions are consistent with the results of the more special dynamical investigations by Fitzgerald and Voigt.

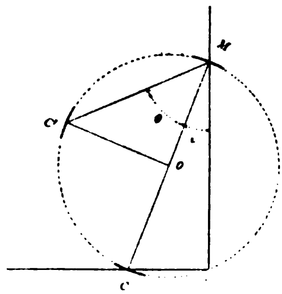
[For a further account of the subject of this paper, and abstracts of some of the papers quoted, reference may be made to Abstracts Nos. 115–120, and Nos. 755–759 (1898); also Nos. 246 and 422–427 (1899).] J. J. S.

822. *Theory of Magneto-Optic Effects.* **W. Voigt.** (Ann. d. Physik, 1. 2. pp. 389–398, Feb., 1900.)—The author extends his theory, which was hitherto limited to waves propagated parallel or normal to the magnetic lines of force, by allowing the waves to be propagated in any direction. The complete final formulæ are very complicated. Their discussion is therefore limited to the two practically most important cases, where the line investigated belongs to a region of nearly vanishing absorption, or lies in the neighbourhood of a sharp absorption band. The first case yields formulæ for a kind of generalised Faraday effect, the latter gives those for the general inverse Zeeman effect. The latter may also be applied to the absorption bands themselves, and they thus, with the aid of *Kirchhoff's theorem*, yield the laws of the dire

Zeeman effect in any direction of propagation. The differences in velocity, absorption, and ellipticity encountered in passing from a sharp absorption band to a region of vanishing absorption, are remarkably great. E. E. F.

823. *Arc Spectrum of Vanadium.* **B. Hasselberg.** (Astrophys. Journ. 10. pp. 343–361, 1899 ; 11. pp. 67–88, Jan., 1900 ; Köngl. Svenska. Vetenskaps-Akademiens Handlingar, 32. 2. 1899.)—This is the fifth of a series of investigations the author is undertaking with a view of placing the spectroscopy of the metallic elements on a substantial basis. The spectra are taken with a plane diffraction grating, and much of the paper is devoted to the discussion of the probable impurities. Tables are given showing the wave-lengths and intensities of about 450 lines which the author concludes are certainly due to vanadium. The measuring apparatus and method of reduction by interpolation formulæ are also fully described. C. P. B.

824. *Use of Concave Gratings.* **G. B. Rizzo.** (Accad. Sci. Torino, Atti, 34. 15*a*, pp. 794–799, 1898–99.)—Instead of Rowland's normal position of the



telescope or sensitive plate at C (see diagram), the author places it at C′, in a position such that $\sin\theta = 2\sin i$. He thus obtains a normal spectrum which, while as regular as that of Rowland, is considerably more brilliant. E. E. F.

825. *Kinetics of a Line Spectrum.* **E. Riecke.** (Ann. d. Physik, 1. 2. pp. 399–413, Feb., 1900.)—It is usually assumed that the luminous molecules of a gas are composed of a number of vibrating atoms, and that the vibrations of the atoms, or rather of the ions attached to them, produce the light-waves in the ether. If the number of such ions is finite, the condition of the vibrating molecule will be defined by a finite number of general co-ordinates. This conclusion is, however, rendered doubtful by the existence of the multiple series of vibration numbers discovered by Kayser and Runge, which may be represented by formulæ of the type $a - \frac{b}{n^2} - \frac{c}{n^4}$. If these series consist of an infinite number of superimposed partials, a molecule with a finite number of degrees of freedom does not suffice for their production. The author endeavours to find a mathematically correct and an easily imagined system capable of explaining the series of oscillations. The system has the general nature of a set of concentric rings. E. E. F.

826. *New Magneto-Optic Effect.* **R. Dongier.** (Comptes Rendus, 130. pp. 244–245, Jan. 29, 1900.)—The author has discovered a partial polarisation of the light emitted by vacuum tubes under the influence of a magnetic field. It is best observed in the case of the red rays emitted by hydrogen under the

spark discharge. With a magnetic field of 4,000 units acting at right angles to the axis of the tube, an ordinary spectroscope only shows a diminution in the intensity of the radiation. But a Savart polariscope reveals the fact that the radiation has become partially polarised. The light emitted in a plane normal to the axis of the tube differs according to its azimuth. The greatest proportion of polarised light is found in a direction normal to both the tube and the field. There are two such directions, and they again differ in optical properties among themselves. That direction shows the maximum of polarised light, which is such that the observer can, by a right-handed rotation of 90°, bring the vector representing the magnetic field into coincidence with the vector of the electric field inside the tube. The fringes observed can in fact be made to appear and disappear by commutating either the current or the field. A red glass should be used to intercept the other rays. Similar effects, though less well marked, are observed in nitrogen, carbonic acid, argon, and chlorine. E. E. F.

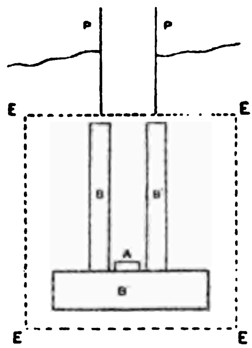
827. *Absorption of Röntgen Rays by Aqueous Solutions of Metallic Salts.* **Blythswood** and **E. W. Marchant.** (Roy. Soc., Proc. 65. pp. 413–428, 1899.)—The absorption produced by normal aqueous solutions of metallic salts having the same acid radicle increases with increase of atomic weight of the base. Metals belonging to the alkali group are not very absorbent, neither are those belonging to the Ca, Sr, and Ba groups, their atomic weight being taken into consideration. Bromides and iodides of the metals are all highly absorbent. With the three common acids the order of increasing absorptive power is nitrate, chloride, sulphate. The absorption produced by a salt is dependent mainly on the atomic weight of its constituents. The amount of absorption produced by a given thickness of a solution of a metallic salt is not proportional to the amount of salt in solution, but appears to follow approximately a logarithmic law. The amount of absorption varies logarithmically with the thickness of the solution traversed by the rays, and the percentage absorption may be represented by an equation of the form $r = \log(\lambda t + \mu)$, where λ is a constant, depending on the nature of the solution and on the penetrative power of the X-rays, and t is the thickness of the solution traversed. For the apparatus used the value of μ would seem to be negligible. A. D.

828. *Velocity of Röntgen Rays.* **B. Brunhes.** (Comptes Rendus, 130. pp. 127–130, Jan. 15, 1900.)—By a method based on the action of Röntgen rays on explosive potentials at different distances, the author finds that Röntgen rays have a definite velocity of the order of the velocity of light. A. D.

829. *Radiography with Three-Phase Currents.* **Delézinier.** (Comptes Rendus, 130. pp. 169–170, Jan. 22, 1900.)—The author has done some further work with the system of three-phase radiography devised by him. (See 1900, Abstract No. 470.) He has found that the connections between the electrodes of the Röntgen tube and the two terminals of the induction coil may be reversed without altering the efficiency of the tube. With the aid of a Wehnelt interrupter and an induction coil any three-phase lighting circuit may be used for radiography. E. E. F.

830. *Magnetic Deflection of Becquerel Rays.* **P. Curie.** (Comptes Rendus,

show a very different behaviour in a magnetic field in accordance with the mode of preparation of the substance. The author studies the magnetic deflection of various rays quantitatively by means of the apparatus shown in the diagram. BB′B″ are blocks of lead containing the radiant substance A. PP′ are two plates kept at a difference of potential of 500 volts. Ordinarily the rays proceeding from A pass between the plates and cause a measurable current to pass between the plates. But when a magnetic field is established at right angles to the plane of the paper over the region EEEE the rays are



generally deflected and absorbed by the lead masses, so that they no longer ionise the air between P and P′. Experiments with various samples of radio-active barium carbonate show that the rays are deflected to a very different extent. It is found that those rays which have the greatest penetrative power are most easily deflected by a magnet. The rays which are not deflected penetrate the air at ordinary pressure only to a distance of 6 or 7 cm. The relation between penetration and magnetic deflection marks a fundamental difference from the Röntgen rays. E. E. F.

831. *Penetration of Becquerel Rays.* **Mme. S. Curie.** (Comptes Rendus, 130. pp. 76–79, Jan. 8, 1900.)—Becquerel rays are more easily absorbed when they have already penetrated an absorbing layer than when they have not. This is due to the fact that the less penetrative rays are absorbed in the first absorptive layers. An aluminium disc will absorb a certain proportion of polonium rays. A second aluminium disc will absorb an even greater proportion of the remainder. Polonium rays are not deflected by a magnet, and are propagated in straight lines. E. E. F.

832. *Manganese in Fluorescent Screens.* **J. R. Mourelo.** (Comptes Rendus, 129. pp. 1236-1238, Dec. 26, 1899.)—Several recipes are given for making brilliant fluorescent screens containing manganese as an active substance. In one of them, 100 parts of $SrCO_3$ are mixed with 80 of sulphur and 0·2 of $MnSO_4$. The mixture is kept three hours at a red heat in an earthenware crucible. The resulting sulphide is nearly white, very hard, and shows a bright, greenish-yellow fluorescence. A still better product is obtained by adding to 100 gms. $SrCO_3$ 50 cc. of water containing 2 gms. of dried Na_2CO_3 and 0·5 gm. of fused NaCl. The mixture is desiccated and calcined, and 80 gms. of sulphur and 0·2 gm. $MnSO_4$ are added to the product. The subsequent heating produces a sulphide which only requires a very short exposure. Freshly prepared manganese carbonate is even better than the sulphate. All the manganese screens are greenish-yellow, while the bismuth screens are greenish-blue. (See also 1899, Abstract No. 1145.) E. E. F

833. *Fluorescent Screens.* **J. Precht.** (Ann. d. Physik, 1. 2. pp. 420–428, Feb., 1900.)—The author studies the modifications of the radioscopic pictures observed immediately after commencing work. Zinc sulphide screens at first show the hand as solid, and the bones only gradually appear. The time varies from a few seconds to a minute, and is, generally speaking, the shorter the higher the spark potential, and the "harder" the tube. Shorter intervals are obtained with barium platinocyanide screens, and these have the advantage that the fluorescence ceases with the illumination. The author has not been able to prove the existence of any chemical action producing the time effect, and therefore inclines towards an emission theory of Röntgen rays. E. E. F.

834. *Relation between Constitution and Fluorescence.* **J. T. Hewitt.** (Chem. Soc., Proc. 16. pp. 3–4, Jan. 24, 1900.)—The molecules of substances showing the phenomenon of fluorescence are probably capable of vibrating in two different periodic times; this property would hence be looked for in compounds exhibiting tautomerism, as indeed is the case, almost without exception, with fluorescent colouring matters. Many substances, however, although behaving tautomerically, do not show well-marked fluorescence, possibly owing to the fact that the velocity of change from one tautomeric form to the other in a solution containing the two forms in equilibrium is so small as to allow only a very small proportion of the molecules to absorb energy when in the one configuration and emit it when in the other. When, however, one of the tautomeric forms is symmetrical, the author supposes the molecular structure to be continually undergoing change in a manner analogous to the motion of a pendulum; the symmetrical form first suffers intramolecular displacement to one side, yielding a non-symmetrical form, which then reverts to the symmetrical modification, and this again undergoes displacement, but on the other side of the molecule. The peculiar doubly symmetrical molecular structure necessitated by this theory is possessed by fluorescein and most other fluorescent dye-stuffs; many of the exceptions are probably only apparent, and may be explained when their spectra are more closely examined. T. H. P.

REFERENCES.

835. *Astronomical Objectives.* **H. Harting.** (Zeitschr. Instrumentenk, 19. pp. 274–275, 1899.)—A discussion as to the author's methods of calculation and Leman's modification of the same. [See Abstracts Nos. 1844 (1899) and 482 (1900).]

836. *Electromagnetic Theory of Dispersion.* **P. Drude.** (Ann. d. Physik, 1. 2. pp. 437–440, Feb., 1900.)—This author claims that the theory of dispersion referred to by several authors as that of Hertz is mainly his own, and quotes the letter which Hertz wrote to him on the subject in full. The letter does not contain the formulæ developed by the author, but only a few general suggestions. E. E. F.

HEAT.

837. *Thermal Deformation of Crystallised Normal Sulphates of Potassium, Rubidium, and Cæsium.* **A. E. Tutton.** (Roy. Soc., Phil. Trans. **192.** pp. 455–498, 1899.)—In a previous paper (see 1898, Abstract No. 1017) the author described an interference dilatometer, by the use of which, owing to the introduction of compensation for the expansion of the platinum-iridium interference apparatus by means of a disc of aluminium laid on the object, the delicate method of Fizeau is rendered equally sensitive in the determination of the expansion of solid substances, notably crystals, which cannot be obtained in blocks of the relatively large size hitherto required. The method is particularly applicable to the cases of those substances, including the crystals of most artificial chemical salts, whose ground surfaces will not take a polish equal to that of glass. In previous papers the author has described the results of the application of his method to the investigation concerning the relations between the morphological and physical properties of the crystals of isomorphous series of salts on the one hand and their chemical constitution on the other, to the thermal deformation of the salts in question.

In the present memoir the results are given of an investigation of the thermal deformation of the orthorhombic normal sulphates of potassium, rubidium and cæsium. After describing the method of preparation of the crystals (the parallel-faced crystal blocks), the improvements on the cutting and grinding goniometer (which is gone into very fully), the procedure in cutting and grinding the crystal blocks and the mode of conducting the observations, the determinations and computations are explained. The results of the series of observations are given very fully in extensive tables. The comparison of the coefficients of lineal and cubical expansion of the three sulphates is then considered. The principal results and conclusions deduced are as follows:—

1. The most striking result of the investigation is seen by comparing th cubical coefficients of expansion. The coefficients of cubical expansion o the orthorhombic crystals of the three normal sulphates of potassiu rubidium, and cæsium exhibit a progression corresponding to the progressio of the atomic weights of the three respective metals. This progressio occurs in the case of both the constants a and b in the general expression fo the coefficient of cubical expansion $\alpha = a + 2bt$ for any temperature t.

2. The order of progression of the two constants is inverted; a, th coefficient for 0°, diminishes with increasing atomic weight of the met while b, half the increment of the coefficient per degree of temperatu increases.

3. The coefficients of cubical expansion of the three salts converge wi rise of temperature towards equality, which they reach at about 186°. Bey this temperature the coefficients of expansion exhibit increasing divergence, order of progression being inverted, an increase in the atomic weight of metal being now accompanied by an increase in the coefficient of cub expansion.

4. The thermal deformation is of the nature of an expansion ir *directions in* the crystals of all these sulphates.

5. The coefficients of linear expansion for any one direction of the three salts do not exhibit any progression corresponding to that of the atomic weights.

6. The increment of the linear coefficient of expansion for the direction of the vertical axis *c* of each salt is about twice as large as the increments for the other two directions *a* and *b*, for which latter the increments are nearly equal.

7. The amount of expansion along the direction of the crystallographical axis *b* is approximately identical for all three sulphates, indicating that interchange of the metals is without influence on the thermal behaviour along the macro-diagonal axis of the crystals. The crystals of all three salts also expand least in this direction, which is therefore the common minimum axis of the thermal ellipsoid. The maximum thermal axis is identical in all three salts with the optical first median line.

8. At higher temperatures the same relations still obtain for the potassium and cæsium salts, but at 50° the crystals of rubidium sulphate are apparently thermally uniaxial, owing to the great increment of expansion along the axis *c*.

9. In general a close parallelism between the linear thermal expansion and the directional optical behaviour is seen to exist, and the same progressive effect of variation of the atomic weight of the metal affects both, but in the former case it is masked.

As in the case of the alkaline selenates investigated by the author the general principle holds good that the difference in the nature of the elements of the same family group, which is manifested in their regularly varying atomic weights, is also expressed in the similarly regular variation of the character of the crystals of an isomorphous series of salts of which these elements are the interchangeable constituents. J. J. S.

838. *Thermal Expansion of Liquids.* **G. Guglielmo.** (Accad. Lincei Atti, 8. pp. 271–276. and 310–316, 1899.)—The author describes a modification of Dulong and Petit's method of measuring the absolute thermal expansion of liquids, by which the sensitiveness of the method is greatly increased. Instead of two vertical tubes only, kept at different temperatures, a long tube is used which is bent into a kind of spiral of rectangular section. The whole of the vertical portions on one side are kept at the higher temperature, and the whole of the vertical portions on the other side are kept at the lower temperature. The differences of pressure so produced are thus added up, and the displacement of the levels in the open terminal portions is multiplied by the number of turns, without a serious increase in the sources of error.

E. E. F.

839. *Thermal Conductivity of Heat Insulators.* **C. G. Lamb** and **W. G. Wilson.** (Roy. Soc., Proc. 65. pp. 283–288, 1899.)—A method of testing the comparative efficiency of materials used as insulators is described. The method was devised with the object of using lower temperatures and smaller ranges than had been used in previous experiments, to attain a perfectly steady state of heat transference, and allow of greater accuracy and simplicity in the measurements. The substances used were tested in the dry state, and include air, sawdust, charcoal, hair felt, &c. The method used consisted in placing the material under test in the space between two cylindrical copper pots, kept at a definite distance apart by pieces of vulcanised fibre; the inner

cylinder open at the top and with holes at the bottom, was put inside to direct the currents of air over the inner surface of the inside pot. Energy was supplied electrically to a heating coil within; as well as to the motor: this constituted an internal supply of heat, which maintained the temperature within the pot at any decided upper limit. The motor and coil were connected in series, and leads were carried through a small hole in the lid of the pots to measure the current and potential difference, and thus the power expended on internal heating was measured. The outer pot's surface was kept at a uniform and constant temperature by being immersed in a tank through which water flowed from the mains. The resulting temperature differences were measured by means of thermoelectric junctions of copper and iron. The current was passed steadily into the inner pot, driving the motor and fan, until the inner thermoelectric junction arrived at a steady value; this usually occurred in about three hours; when this was the case the supply of energy by the current was just equal to the heat conducted through the insulator and carried off by the water. Knowing the temperature gradient and the number of watts supplied and the dimensions of the system, the specific conductivity of the material can be deduced.

The following results were obtained :—

Material.	Conductivity.
Air (no baffles)	0·000200
Pine sawdust	0·000242
Pine shavings	0·000162
Brown paper (crumpled up)	0·000167
Hair felt (broken up)	0·000145
Hair felt in two sheets ¼ in. thick each	0·000106
Dry asbestos	0·000297
Charcoal	0·000150
Sand	0·000740
Rice husks	0·000150
Kapok (a heat insulator)	0·000144
Kapok (loose)	0·000122
Silicate cotton	0·000151

In these experiments the temperature differences varied from about 8° to 28°. Hair felt was the best insulator tested. The insulation in the case of brown paper was practically that of air with subdivided spaces; the improvement thus produced in comparison with air only is noticeable. J. J. S.

840. *Measurement of Low Temperatures.* **A. Ladenburg** and **C. Krügel.** (Ber., 32. pp. 1818–1824, 1899, and 33. pp. 637–638, March 12, 1900.)—In using a thermoelectric couple for measuring low temperatures the authors do not consider that it is sufficient to use a quadratic equation, and have therefore made use of a cubic equation to express the relationship between temperature and voltage. The thermal element was compared with a hydrogen thermometer at three standard temperatures, viz., the boiling-point of liquid a — 191·25°; of ethylene, — 102·9°; and the sublimation-point of solid carb dioxide, — 77·5°. From these three fixed points the three constants in the equation were determined, and its accuracy was tested by comparing the readings of the hydrogen thermometer with those of the thermal elemen (1) the boiling-point of methane (— 162°), and (2) the melting-point of e (— 113°); the readings differed by only 0·05° and 0·5° in the two cases.

The boiling- and freezing-points of a number of substances were then determined, and are given in the accompanying table.

Substance.	Boiling-point.	Melting-point.
Oxygen	—182·2° at 745·0 mm.	...
Nitrous oxide	—142·8° at 757·2 mm.	—150·5°
Ammonia	...	— 75·5°
Hydrogen chloride	— 83·1° at 755·4	—111·3°
Hydrogen bromide	— 68·1° at 755·4	— 86·13°
Hydrogen iodide...	— 36·7° at 751·7	— 51·3°
Hydrogen sulphide	— 60·4° at 755·2	— 82·9°
Methane	—162° at 751·0	...
Ethane	— 84·1° at 749·0	—172·1°
Propylene...........	— 48·2° at 749·0	remains liquid at — 190°
Trimethylene	about — 34° at 749·0	—126·6°
Acetylene	— 82·4° (sublimation point)	sublimes
Toluene...............	+110°	— 93·2°
Ethylbenzene	+135 to +136°	— 93·2°
Mesitylene	+164°	— 57·5°
Cymene...............	....	— 73·5°
Methyl chloride ...	....	—102·9°
Ethyl bromide......	....	—115·8°
Ethyl iodide.........	....	—110·6 to —113·1°
Methyl alcohol......	....	— 93·9°
Ethyl alcohol	....	—111·8°
Ether..................	....	—113·1°
Aldehyde	....	—120·6°
Acetone...............	....	— 93·9°
Glycol	....	— 15·6°
Methyl formate ...	+32–33°	—100·4°
Ethyl acetate	....	— 82·4°
Ethylamine	+19–20°	— 83·8°

Mesitylene and alcohol solidify in liquid air to a transparent amorphous mass, but become crystalline when the temperature is allowed to rise; ether, aldehyde, and acetone crystallise directly. T. M. L.

841. *Co-volume of Fluids.* **D. Berthelot.** (Comptes Rendus, 130. pp. 115–118. Jan. 15, 1900.)—The kinetic theories lead to equations of the form—

$$p + \frac{a}{v^2} = \frac{RT}{v}\left(1 + \frac{b}{v} + a_1\frac{b^2}{v^2} + a_2\frac{b^3}{v^3} + \dots\right)$$

When the pressure is small and the volume great, powers of $\frac{b}{v}$ beyond the first may be neglected. In any case, the above equation represents very faithfully the isothermals obtained by van der Waals. But these deviate from experiment just in those parts where the pressure is smallest. The author proposes to regard the co-volume as a function of the temperature, according to the equation—

$$b_T = b_c\left\{1 + 0·3\left(\frac{T}{T_c} - 1\right)\right\}$$

where b_T is the co-volume at temperature T, and b_c the co-volume at the critical temperature. This leads to equations which may safely be applied to liquids. E. E. F.

842. *Internal Pressure of Gases.* **D. Berthelot.** (Comptes Rendus, 130. pp. 69–78, Jan. 8, 1900.)—The author compares the total results of experiment available up to the present with the various formulæ proposed for the characteristic equation of fluids, and arrives at some simple and satisfactory formulæ applicable to the liquid state. The reasoning employed is based upon the law of corresponding states. Since the characteristic equation may contain only three constants special to the body under investigation, the author only considers equations involving three such constants. From these he deduces, by Sarran's method, the elements of the critical point and the reduced equations common to all bodies. The critical isothermals so obtained are compared with the experimental critical isothermal of carbonic acid as a standard. Van der Waal's formula agrees with Amagat's experimental results for higher values of ω, but not for the lower values. The modified form introduced by Clausius agrees for the lower values but not for the higher values. To obtain a complete agreement, the author goes a step further than Clausius, and substitutes for the term $\frac{a}{v^2}$, not $\frac{a}{(v+nb)^2}$ but $\frac{a}{v^2+2\,lvb+mb^2}$. The revised formula may be used for liquids by inserting three constants characteristic of the body in question, preferably the critical pressure and temperature and the molecular weight. E. E. F.

843. *Liquefaction of Gaseous Mixtures.* **F. Caubet.** (Comptes Rendus, 130. pp. 167–169, Jan. 22, 1900.)—The author has constructed the limiting lines for ten mixtures of methyl chloride and carbon dioxide, of composition varying between 10 and 90 per cent. The results are given in the form of a figure which shows also the critical line and the lines of evaporation and condensation. Retrograde condensation is shown by all the mixtures, and is particularly well marked for 40 per cent. of methyl chloride. R. A. L.

844. *Heat of Sublimation of Carbonic Acid.* **U. Behn.** (Ann. d. Physik, 1. 2. pp. 270–274, Feb., 1900.)—If the mean specific heat of any solid is known between 18° and —79° or —186°, it is easy to determine the heat of sublimation of solid CO_2, or the heat of evaporation of air with its aid. It is only necessary, in the latter case, to introduce the body of known temperature into boiling air. The air will go on evaporating until the body has the temperature of the boiling-point of air, and it only remains to measure the volume of gaseous air. The quantities thus determined by the author with the aid of an aluminium cylinder are—

CO_2, heat of sublimation : 142·4 calories.
Air, heat of evaporation : 50·8 calories.

From these figures, the specific volumes of gaseous CO_2 at —79° and gaseous air at —186° may be found. They are 423 and 358 respectively. E. E.

SOUND.

845. *Reflection of Sound at a Paraboloid.* **H. J. Sharpe.** (Cambridge Phil. Soc., Proc. 10. pp. 101–136, 1899.)—A sound-reflecting paraboloid of revolution is placed with its axis corresponding with that of x, and sound vibrations are going on within the paraboloid and are reflected by the surface. The source of sound may be at an infinite distance or at the focus of the reflector or elsewhere within it. In the present paper the motion is assumed to be symmetrical about the axis. The author does not here discuss the case which he says is the most interesting, viz., that in which the source is at the focus, but the next most interesting case is treated, viz., that in which we have a line of sources extending from the vertex for a finite distance along the axis. The treatment is subdivided according to the values of the constant A in the equations $V\frac{d^2V}{dv^2}+\frac{dV}{dv}+(p^2v \pm A)V=O$, the most important cases being when A is large. S. H. B.

846. *Electric Transmission of Sound.* **Dussaud.** (Comptes Rendus, 129. pp. 880–881, 1899.)—The electric transmission of sound (see 1899, Abstract No. 560) is the more efficient the greater the number of the microphone membranes enclosed in the resonator box, and the efficiency is also increased by letting the air act upon both faces of the membranes. At the receiving station the electromagnet should have several faces, each actuating a diaphragm, and the sound should be collected from both faces of the diaphragms. The intensity of the transmitted sound is then sufficient to work a phonograph. It has been found possible to thus record telephonic communications over several miles of wire, and also to take down a speech delivered in a remote part of a building and reproduce it from the phonograph in the lecture theatre, practically without loss of intensity. E. E. F.

847. *Sensitive Flame Tests on a Telephone Transmitter.* **Rayleigh.** (Roy. Instit., Proc. 15. pp. 786-789, 1899.)—Lord Rayleigh describes a special sensitive flame made by a pin-hole (0·03″) jet, over which is a chamber one side of which is fitted with a diaphragm of paper or a transmitter diaphragm. Experiments with an induction balance and an alternating current are given which can be shown by the flame in a lecture demonstration. M. O'G.

ELECTRICITY.

848. *Electromagnetic Theory.* **A. Scheye.** (Zeitschr. Phys. Chem. 32. pp. 145–149, Feb. 6, 1900.)—The author replies to Wedell-Wedellsborg (see 1900, Abstract No. 96), who gives two grounds for doubting the existence of the electric field due to a galvanic current: firstly, that it does not agree with experiment; secondly, that it leads to inconsistent results. The author agrees with the first objection so far as to admit that further decisive experiments are required. The second objection he combats in the present paper, maintaining that as the six equations expressing Maxwell's theory are consistent with each other, we cannot, if we confine our assumptions to them, arrive at inconsistent results. This he illustrates by the example of a fixed circuit and the introduction of another circuit into its field; and by discussion of the galvanic circuit of two metals and an electrolyte. This he says leads to Maxwell's expression for the energy of the field.

$$\int \frac{K}{4\pi}\left\{\left(\frac{d\phi}{dx}\right)^2 + \left(\frac{d\phi}{dy}\right)^2 + \left(\frac{d\phi}{dz}\right)^2\right\} d\tau.$$

where ϕ is the potential. He agrees with Wedell-Wedellsborg that strictly in electric induction we cannot regard resistance as constant. And we may assume, he says, that an electric potential exists even in a non-stationary state, depending in the same way on the currents for the time being as in the stationary state. But this assumption, he points out, involves difficulties.
S. H. B.

849. *Hydro-dynamical Hypothesis of Electromagnetic Actions.* **G. F. FitzGerald.** (Roy. Dublin Soc., Proc. 9. pp. 50–54, 1899.)—After referring to Kelvin's investigation as to a possible transference of a laminar wave disturbance through a turbulent liquid (Phil. Mag. v. vol. 24. p. 342, 1877), and his subsequent calculation of a stable, steady motion for a hollow vortex surrounded by a tore round which the liquid is circulating (Roy. Irish Acad. Proc. iii. vol. 1. p. 340, 1889), the author proceeds to explain his own hypothesis, according to which the ether is a turbulent liquid, the Faraday tubes being represented by vortex spirals. A vortex filament, the author points out, can have a spiral wave superposed on it, and the irrotational motion in the neighbourhood of such a spiral will be essentially the same as the distribution of magnetic force near a similar spiral wire conveying an electric current. The author next considers the transference of spirality from one vortex to another, and arrives at equations which are identical with the fundamental equations of wave propagation in the ether. An electric charge is represented by a singular point on a vortex spiral, at which the flow of fluid is away from the point on both sides, the spirality on one side being right-handed, and that on the other left-handed.
A. H.

850. *Electromagnetic Rotations.* **Raveau.** (Comptes Rendus, 130. pp 31–32, Jan. 2, 1900.)—This is a reply to Lecher's criticism of König's experi ment (see 1900, Abstract No. 94). Though it is immaterial to the final resu whether the point of application of the electromagnetic forces is absolute final or not, the lack of definiteness in fixing it leads to ambiguities in tl point of view adopted. To explain Faraday's electromagnetic rotation,

which one of the poles of a vertical magnet describes a circle about a portion of a vertical straight conductor carrying a current, it is maintained, from the point of view of Biot and Savart, that the motion is determined by the action of the current upon the neighbouring pole. According to Ampère's view, on the other hand, the force exercised by the part of the circuit meets the vertical wire and cannot produce any rotation about it. These two views are not incompatible, as their application depends upon different conditions. Lecher's experiment, in which no rotation is produced, differs from Faraday's arrangement by the substitution of two joints for the movable contacts.

E. E. F.

851. *Potentials and Capacities where the Dielectrics are Heterogeneous or Conducting.* **A. A. Petrovsky.** (Comptes Rendus, 130. pp. 112–115, Jan. 15, and 164–166, Jan. 22, 1900.)—Starting with Maxwell's form of Laplace's equation the author obtains the following results for capacities:—

(1) *Plane condenser* with plates of area S, and dielectric of n layers, d_i and K_i denoting the thickness and dielectric constant respectively of the layer whose number is i:

$$\text{Capacity} = S \div 4\pi \sum_{i=1}^{i=n} \frac{d_i}{K_i}$$

(2) *Spherical condenser* with n concentric spherical layers of dielectric:

$$\text{Capacity} = 1 \div \sum_{i=1}^{i=n} \frac{1}{K_i}\left(\frac{1}{r_{i-1}} - \frac{1}{r_i}\right)$$

(3) *Cylindrical condenser* with n coaxial cylindrical layers of dielectric:

$$\text{Capacity} = \text{Length} \div 2 \sum_{i=1}^{i=n} \frac{1}{K_i} \log \frac{\rho_i}{\rho_{i-1}}$$

The potential is next obtained round a sphere immersed in a concentric sphere of conducting dielectric. In conclusion follows a discussion of the experimental determination by alternating currents of the capacity of a condenser with heterogeneous dielectrics. E. H. B.

852. *Atmospheric Electricity.* **G. Schwalbe.** (Ann. d. Physik, 1. 2. pp. 294–298, Feb., 1900.)—As against Pellat's obervation of an apparent loss of charge due to evaporation (see 1899, Abstracts Nos. 562 and 1375), the author has repeated his experiments, which show that a metallic vessel filled with hot water does not lose its charge. In this case he employed potentials as high as those employed by Pellat, and made separate observations for positive and negative charges. The results obtained were the same as before, and the author is convinced that no electric charge is conveyed by evaporation. Hence Enner's theory of atmospheric electricity is inadequate. E. E. F.

853. *Diselectrification Produced by Magnetism.* **C. E. S. Phillips.** (Roy. Soc., Proc. 65. p. 320, 1899.)—Under certain conditions an electrified body rapidly loses its charge when in the neighbourhood of a magnetic field. The phenomenon is only exhibited at pressures lower than 0·2 mm. of mercury. A glass tube has two tinfoil coatings, one inside and one outside. The former is electrified positively, and the "free" charge on it indicated by an electroscope: this charge induces a "bound" charge on the outside coating. On actuating an electromagnet whose poles protrude through the ends of the glass tubes the leaves of the electroscope suddenly collapse. No such effect is observed when the inner coating is charged negatively. D. E. J.

854. *Electrographs.* **E. Gates.** (Electricity, N.Y. 17. pp. 359–360, 1899. From the Photographic Times.)—Illustrations are given of electrographs formed by the passage of an electric discharge through and over a photographic plate. In order to obtain these effects a camera is unnecessary. It is sufficient to enclose the plates in a light-proof envelope. The plates when developed exhibit a foliated appearance of great delicacy, similar to that of certain varieties of seaweed. R. A.

855. *Point Discharges.* **H. Sieveking.** (Ann. d. Physik, 1. 2. pp. 299–311, Feb., 1900.)—Discharge of statical electricity from a point always occurs at a lower potential in the case of negative charges than it does in the case of positive charges. Under equal conditions the quantity of negative electricity discharged is always greater than the quantity of positive electricity. The quantity discharged, either upon a disc or upon the inner surface of a conducting sphere, may be represented by the formula $E = a\ (V - b)$, when b is the minimum discharge potential. The formula applies to potentials lying between the minimum potential and 5,000 volts. For higher potentials Warburg's formula $E = cv(V - M)$ is more in agreement with experiment. The minimum potential is nearly constant at greater distances, but increases rapidly at smaller distances. The gases investigated may be arranged in a series according to their power of furthering negative discharges. Oxygen is at the head of this series, and carbonic acid at the end. E. E. F.

856. *Discharges in an Electrostatic Field.* **J. Stark.** (Ann. d. Physik, 1. 2. pp. 430-436, Feb., 1900.)—Various effects in the way of stopping or facilitating the discharge of a battery through a rarefied gas may be brought about by bringing conductors variously charged into the neighbourhood of the vacuum tube. Whenever such conductors have the effect of increasing the difference of potential between the electrodes, the discharge is facilitated; otherwise it is rendered more difficult, and usually made intermittent. Such intermittent discharges are capable of setting up vibrations in the kathode, which can be heard on bringing the ear close up to the tube, or wrapping a strip of tinfoil loosely round the tube in the neighbourhood of the kathode. When the electrodes consist of flexible wires or carbon filaments, the kathode often exhibits strong oscillations, whereas the anode remains steady. The difference between the anode and the kathode is probably due to the greater drop of potential at the kathode, which makes it more sensitive to variations of the field between itself and the walls. E. E. F.

857. *Duration of Electric Spark.* **H. Abraham** and **J. Lemoine.** (Comptes Rendus, 130. pp. 245–248, Jan. 29, 1900.)—The method employed to test for a retardation in the disappearance of the Kerr phenomenon (see 1899, Abstract No. 1859) may also be used for determining the duration of the electric spark and studying its initial stages. It is found that the total quantities of light emitted by the spark is much less than 40 times that which is emitted during the time required for the cessation of the Kerr effect. That time, as we know, does not exceed 1/100th of a micro-second. If the spark has a uniform intensity over its whole duration, we may suppose that its duration is much less than 0·4 micro-second. Another conclusion arrived at is that in about 1/400th of a micro-second the spark reaches a considerable brightness, not far from its maximum brightness. The disappearance of the Kerr phenomenon as studied with the author's apparatus consists of the three elements, and involves the time during which the Kerr condenser

discharges itself, the time during which the carbon bisulphide preserves its bi-refracting power after the withdrawal of the field, and the time required for the establishment of the spark. Each of these processes, taken separately, has a duration not exceeding a hundred-millionth of a second.

E. E. F.

858. *Break-up of a High-Potential Current into Disruptive Discharges.* **H. Abraham.** (Soc. franç. Phys., Séances, 2. pp. 70–77, 1899.)—A high-voltage transformer, actuated by an alternating current; the terminals of a condenser connected with the poles of the transformer, and also with the two electrodes of a deflagrator. On working in the first place without blowing the air away in the deflagrator, a sufficient current will produce a true flame in the deflagrator, the brightness of which follows the alternations of the current, the flame being almost extinguished at each alternation. Like the electric arc, this flame has one pole brighter than the other. With a flame of 2 cm. length and a current of 0·0485 amperes the electromotive force at the poles of the deflagrator is 2,550 volts, showing a resistance of 53,000 ohms; but with the same length of flame under a current of 0·020 amperes the cross-section of the flame is reduced and the voltage becomes 3,400 volts, showing a resistance of 170,000 ohms. The transformer must be able to set up these differences of potential at each alternation as well as to feed the alternating current through the flame. If the current be progressively reduced the requisite differences of potential go on increasing; so that at a given moment the *régime* of flame is transformed into one of disruptive discharges, each discharge lighting up a flame which lasts until the end of the half-period if the actuating current be still sufficiently high for this. There is, however, a continuous gradation between the condition of flame and that of disruptive discharges, for each discharge modifies the air through which it passes and renders it more conductive, so that successive discharges are more and more flame-like. It is difficult to show this by adjusting the actuating current, but it can be readily shown by blowing away the air from between the plates by progressively strengthening currents of air or carbonic acid. If the current of air be very strong the *régime* of disruptive discharges becomes stable and regular, the flow of sparks following the alternations of the actuating current quantitatively according to the sine law. With carbonic acid at a pressure of 3 kg. per sq. cm. more than 100,000 sparks per second were obtained; with air at a pressure of 2 metres of water about 10,000 per second. The phenomenon has a wide range of stability. (See also 1899, Abstract No. 1495.) A. D.

859. *Lichtenberg Figures inside Röntgen Tubes.* **E. Riecke.** (Ann. d. Physik, 1. 2. pp. 414-419, Feb., 1900.)—It is not necessary to employ a mixture of red lead and sulphur in order to bring out Lichtenberg figures opposite the kathode. On close examination of the fluorescent patch it is seen that it branches out into club-shaped projections, dark on a light ground, evidently owing to local negative charges which repel the kathode particles and diminish the fluorescence. Branching structures are also produced, chiefly in a zone adjoining the narrow fluorescent band in the plane of the kathode itself, but also round the fluorescent patch opposite when the tube is "hard." These structures mark lines along which the negative charge, accumulated in the fluorescent patch, travels outward into the positive regions. The multiplicity of the branches is probably due to the fact that the patch has a wavy contour which keeps rapidly fluctuating. E. E. F.

860. *Hall Effect.* **G. Moreau.** (Comptes Rendus, 130. pp. 122–124, Jan. 15, 1900.)—The thermo-magnetic effect discovered by Nernst and Ettinghausen in 1886 may be derived from the Hall effect with the aid of the Thomson effect. The author formulates the former by the equation—

$$e = \frac{K}{\omega}\frac{HJ}{\varepsilon}$$

where e is the E.M.F. developed in a thin metallic plate of the thickness ε by a flux of heat J and a magnetic field H at right angles to the flux and the current; ω is the conductivity of the metal and K a constant. The Hall effect is similarly represented by—

$$E = c\frac{H}{\varepsilon} I$$

where I is the current strength.

If two neighbouring sections of the plate are separated by a distance Δx, and are traversed by a flux of heat, producing a difference of temperature Δt between them, a difference of potential ΔV is produced in accordance with the Thomson effect, and we have—

$$\Delta V = \sigma \Delta t$$

where σ is the "specific heat of electricity" in the plate. The E.M.F., $\Delta V/\Delta x$ per unit of length gives rise under the influence of a magnetic field to a transverse E.M.F. in accordance with the Hall effect. The equation for the Hall effect gives—

$$E = \frac{c}{\rho} H a W$$

where W is the E.M.F. of the primary current, I per unit length, and ρ the resistivity of the plate. Putting $W = \Delta V/\Delta x$ we have for the thermo-magnetic effect—

$$\varepsilon = \frac{c\sigma}{\rho} H a \frac{\Delta t}{\Delta x}$$

or, if—

$$K = \frac{c\sigma}{\rho},$$

$$e = KHa\frac{\Delta t}{\Delta x}$$

which is the formula experimentally established by Nernst for his new thermo-magnetic effect.

The calculated and observed results agree well except in the cases of nickel and cobalt. In nickel the calculated effect is only one-third of the observed effect, while in cobalt the value is nearly the same, but the actual sign is positive, while the theoretical sign is negative. No close agreement can be expected unless the mode of preparation of the specimens is rigidly the same. E. E. F.

861. *Electrically Heated Conductors.* **H. Diesselhorst.** (Ann. d. Physik, 1. 2. pp. 312–325, Feb., 1900.)—While limiting the discussion to the simpler problem of an electrically heated conductor as stated by Kohlrausch, admitting, however, any variation of the conductivity with the temperature, the author proves that only a single solution satisfies the differential equation and terminal conditions. He also sketches a method whereby the general integration of the equations can be reduced to a known problem of greater simplicity, involving Laplace's equation. As regards the introduction of t

Thomson effect, he proves in a concrete case that it involves a difference of temperature lying somewhere between 0·05° and 0·5°, whilst the Joulean heating amounts to 6° or 7°. (See also 1900, Abstract No. 187.) E. E. F.

862. *Hysteresis of Resistance.* **H. Chevallier.** (Comptes Rendus, 130. pp. 120–122, Jan. 15, 1900.)—When a wire is subjected to periodic variations of temperature its electric resistance varies in a very irregular manner. If R is its resistance at a temperature T_0, and it is heated to a temperature T_1, and subsequently cooled down to T_0, its resistance will finally be different from R. The difference is due to some allotropic transformation undergone by the metal, which is subject to hysteresis. There is not only a change of temperature, but also a complication introduced by the alternate annealing and tempering of the wire. The author's experiments dealt with a silver platinum alloy which resists oxidation. He made the temperature oscillate a large number of times between T_0 and T_1, and found that the resistance at T_0 acquired values differing from each other by a less and less amount as the alternations proceeded, without the difference, however, disappearing entirely. Several series of 70 oscillations each between 150° and 15° gave final values for 15° amounting to 1·01509, 1·01500, 1·01493, 1·01490, 1·01488, and 1·01487 respectively. The last limiting value is practically final for 15°, but it is disturbed by heating the wire to a temperature above 150°. By repeating the oscillations and introducing the disturbance systematically the author obtains a limit of the limits which completely fixes the final temperature for the range and disturbance specified. E. E. F.

863. *Fault-Testing in Cables.* **J. Garraud.** (Écl. Électr. 22. pp. 139–140, Jan. 27, 1900; Annales télégraphiques, 25. pp. 289–295.)—The author describes methods of finding earth faults of insulation in lead-covered cables by the application of an interrupted current to the circuit and the movement of a bobbin along the external sheath, the bobbin being in circuit with a telephone. As the bobbin moves towards or past the fault, so the sound in the telephone is maintained or ceases altogether. With the telephone, therefore, as the detector the position of the fault may be exactly estimated in a single conductor cable. This is referred to as the method of E. Gerard, used fifteen years ago. But M. Barbarat has developed the idea for finding a fault in a bundle of lead-covered wires to which so simple a process would not be practicable. He ascertains by ordinary means the section of the line in which the fault is situated and its approximate situation, detaches from the bundle the portion of the defective cable comprised between the fault and the shortest end, suspends it by insulating tape or cords, and applying the interrupted current to the far end slides the bobbin along the sheaths until the sound ceases, and thus ascertains the position of the fault.

There is still a further method, according to Garraud, by which such a test may be applied in cases where one end of the cable cannot be separated out—as, for instance, where a wire is laid up helically with others within a lead sheath. If the bobbin be moved along the latter from the point of application of the battery towards the fault the sound in the telephone rises and falls in regular measure owing to the helical position of the conductor up to the position of the fault, but when that is passed the sound diminishes continuously, for the current does not now follow the conductor, and the rhythm has disappeared. The fault is localised where this change is observed. E. O. W.

864. *Addenbrooke Electrometer.* (Elect. Engin. 25. pp. 150–151, Feb. 2, 1900.)—This instrument differs from the ordinary type of quadrant electrometer chiefly in structural details, and cannot be described conveniently in an abstract. A full description with drawings is given in the article. There are two sets of quadrant plates, and their distance apart is adjustable. With the electrometer coupled up idiostatically, and the plates $\frac{1}{8}$ inch apart, an E.M.F. of 1 volt produces a deflection of from 3 to 5 mm. on a scale at 2 m. distance. It is stated, however, that Addenbrooke has obtained a deflection of 80 mm. with the same E.M.F. G. H. B.

865. *Combined Ammeter and Voltmeter.* **M. Aliamet.** (Électricien, 18. pp. 425–426, 1899.)—This instrument comprises an ammeter and a voltmeter of the Weston type mounted in one case, the pointers moving over separate scales on the same dial. The instrument is designed for use on motor-cars driven by accumulators, the ammeter being for this purpose designed to read, *e.g.*, up to 15 amperes in one direction for charging, and up to 100 amperes in the other direction for discharging. C. K. F.

866. *Measuring Instruments for Alternate Currents.* **M. Aliamet.** (Électricien, 19. pp. 1–5, Jan. 6, 1900.)—The instruments are based on the following principle : A metal disc revolves between the poles of an electromagnet ; the poles are partially screened from the disc by the interposition of copper plates ; an alternating current through the electromagnet then produces two fields through the disc, one directly and the other through the screens. These are displaced in regard to phase and position, and consequently produce a rotating field, which gives rise to a turning movement in the disc.

In the ammeters and voltmeters the current passes through the electromagnet, and the pointer is attached to the disc, which is controlled by a watch-spring ; its oscillations are damped by a permanent magnet. In the wattmeter the main current passes through one electromagnet, and the shunt current through two others in series, an inductive coil being inserted in their circuit to produce a difference of phase of approximately 90°.

For high-tension currents the instruments receive the secondary current of a transformer with its primary in the high-tension circuit. For very large currents the same arrangement is adopted in the case of the ammeters and wattmeters, the primary of the transformer being a flat plate of copper which is bolted in a gap in the main conductors. G. H. B.

867. *Power Factor Measurements.* **A. J. Bowie, Jr.** (Elect. World and Engineer, 34. pp. 898–901, 1899.)—This paper considers the power factor of alternating current circuits when the current and potential difference cannot be represented by simple sine curves. The power factor is defined to be the ratio of the true watts to the apparent watts, and the phase difference to be that angle whose cosine is equal to the power factor.

Two special cases are considered, in which (1) the potential difference and the current are respectively given by—

$$e = 10 \sin a + \sin 3a$$
$$i = 10 \sin a + 2 \sin 3a + \sin 5a$$

and (2) they are respectively—

$$e = 10 \sin a - \sin 3a + \sin 5a$$
$$i = 10 \sin a - 2 \sin 3a + 3 \sin 5a$$
$$- 2 \cos a + \cos 3a + \cos 5a$$

Different values of phase difference being assumed, tables are given showing the actual calculated values of the power factor, and the corresponding values on the assumption that the functions may be represented by sine curves. For example, when the phase difference is zero the actual power factor is 0·991 in Case 1, and 0·958 in Case 2. W. G. R.

868. *Magnetisation of Brickwork by Lightning.* **P. Gamba.** (Accad. Lincei Atti, 8. pp. 316–320, 1899.)—The author describes several well-marked instances of the magnetisation of masonry struck by lightning. In a house near Viterbo several magnetised portions of a wall were discovered, one of which marked a point passed through by the discharge. The author believes the magnetisation to be quite independent of terrestrial magnetism, and solely due to the direction of the discharge. He believes with Folgheraiter that most of the fragmentary rocks of the Roman Campagna which exhibit magnetic polarity acquired it through lightning discharges. E. E. F.

869. *Molecular Susceptibility of Paramagnetic Salts of the Rare Earths and of the Iron Group.* **O. Liebknecht,** with **H. du Bois** and **A. P. Wills.** (Ber., 32. pp. 3344–3348, Dec. 11, 1899, and 33. pp. 443–445, Feb. 12, 1900.)—The method used for determining the magnetic susceptibility of a paramagnetic salt consists in neutralising the diamagnetism of the water by the addition of the salt. When this has been done exactly, a meniscus of the solution in a capillary tube does not move either forwards or backwards when placed in a magnetic field.

In the case of the chlorides of the rare earths the molecular susceptibility i_m increases steadily with the atomic weight from yttrium ($i_m = 0·00021$) through cerium, praseodymium, neodymium, samarium and gadolinium to erbium ($i_m = 0·03668$), and then falls abruptly to ytterbium ($i_m = 0·00711$).

A similar maximum occurs in the iron group, in which the magnetic susceptibility of a large number of salts has been determined. The mean values for the molecular susceptibility are as follows :—

	Atomic Weight.	i_m.
Chromium	52·1	0·00615
Manganese	55·0	0·01520
Ferrous iron	56·0	0·01274
Cobalt	59·0	0·01039
Nickel	58·7	0·00441
Copper	63·6	0·00162

For ferric iron the mean values are $i_m = 0·01352$ for the nitrate and chloride, but $i_m = 0·01510$ for the bromide, sulphate, and oxalate, a difference of about 12 per cent. It will also be noticed that iron resembles cobalt more than nickel, although the atomic weight of the latter is supposed to be the smaller. T. M. L.

REFERENCES.

870. *Oscillations round a Theoretical Hertzian Oscillator.* **K. Pearson** and **A. Lee.** (Roy. Soc., Phil. Trans. 193. pp. 159–188, 1899.)—The full text of the paper, of which a preliminary abstract has already appeared. (See 1899, Abstract No. 1169.) The subject is treated from the mathematical point of view.

871. *Magnetism.* **C. Maurain.** (Écl. Électr. 22. pp. 201–206, Feb. 10, 1900.) —An article dealing mainly with the bibliography of the subject in its various aspects.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

872. *Solubilities of Argon, and Helium in Water.* **T. Estreicher.** (Zeitschr. Phys. Chem. 31. pp. 176–187, 1899.)—The author, using a greatly improved form of the apparatus described by Ostwald in his book on physico-chemical measurements, has made a very careful determination of the solubility-coefficients of argon and helium for every fifth degree between 0° C. and 50° C. Helium is found to show a ***minimum*** at about 25°. The author points out that the solubility curve of a gas must show a minimum at some temperature below the critical point of the system, since at that point the solubility becomes infinite. He compares the case of helium with that of hydrogen, which appears to possess a minimum solubility either at 60° C. or somewhere between that and 100° C. A minimum point on the argon curve was not reached. Argon probably possesses a minimum near that of oxygen. From the diagram given by the author, it is seen that the solubility curves for nitrogen and helium intersect at 30° C. To give an idea of the solubilities, the results obtained at 15° C. may be quoted.

Gas.	Vol., measured at 0° and 760 mm., dissolved by one volume of water at 15° C. and 760 mm.
Argon	·04099
Helium	·01896

F. G. D.

873. *Colloid Solutions.* **G. Bredig** and **A. Coehn.** (Zeitschr. Phys. Chem. 32. pp. 129–132, Feb. 6, 1900.)—A criticism of the work of Stoeckl, Vanino, and Stark (see 1899, Abstracts Nos. 1740 and 1741), many of whose results are said to have been anticipated by other observers whom they fail to notice. Experiments by Bredig seem to disprove Stark's theory as to the connection of air-bubbles with the precipitation of colloid metallic solutions.

N. L.

874. *Colloidal Cadmium.* **G. Bredig.** (Zeitschr. Phys. Chem. 32. pp. 127–128, Feb. 6, 1900.)—Except under special conditions the preparation by chemical means of colloid solutions of metals more electropositive than hydrogen is impracticable, since water would necessarily be directly decomposed by the reducing agent employed. If, however, an electric arc is formed under water between cadmium electrodes, using a current of 5–10 amperes at 30–40 volts, a dark brown solution of the metal is obtained, which gradually oxydises on exposure to air, and is coagulated by the addition of electrolytes. A solution of zinc was also obtained in the same way, but this is very unstable. N. L.

875. *Relations between the Atomic Weights and Physical Properties of Elements.* **T. Bayley.** (Chem. News, 80. p. 282, 1899.)—It is pointed out that the product of the absolute melting-point and the coefficient of linear expansion is approximately constant for many elements, and equal to about 0·02. In the case of magnesium, silver, sulphur, sodium, and potassium, higher values are found—0·024 to 0·028. From this relation it follows that atomic expansion, measured from absolute zero to the melting-point,

varies directly as the atomic volume. It is also shown that among elements of similar character simple relations exist between the values found for the ratio of the atomic heat to the square of the atomic weight. Thus the value of this ratio for potassium is very nearly one-third of the value for sodium, and the value for zinc is half that for copper. N. L.

876. *New Spectrum Lines of Argon.* **R. Nasini, F. Anderlini,** and **R. Salvadori.** (Accad. Lincei Atti, 8. pp. 269–271, 1899.)—The author announces the discovery of some new lines in the infra-red spectrum of argon. They are six in number, and all rather faint. Their wave-lengths are: 798·0; 808·0; 814·0; 832·0; 845·0; and 857·5. The material from which the argon was obtained was taken from a fumarole of Vesuvius. The spectrum shows all the usual lines of argon, though their intensities are distributed in a somewhat different manner. E. E. F.

877. *Hydrolysis of Chloride Solutions on Standing or by Light.* **F. Kohlrausch.** (Deutsch. Phys. Gesell., Verh. 1. pp. 259–264, 1899.)—The author shows that the gradual hydrolysis which takes place in aqueous solutions of platinum tetrachloride, as evidenced by a decrease of the electrical conductivity, is caused mainly by the action of light. Sunlight accelerates the hydrolysis to a much greater extent than diffused daylight, whilst light passed through a yellow glass exerts very little influence, this being also the case with incandescent gas light. The action on strong solutions is relatively slower than with weak. Hydrogen platinichloride shows similar behaviour, the hydrolysis of dilute solutions being considerably accelerated by the action of light; strong solutions, however, show no change in conductivity, either spontaneous or caused by light. Gold chloride is not sensitive to light, but when a dilute solution is left in the resistance cell a change occurs in which the platinum-black of the electrodes takes part. The author's observations on stannic chloride have been partially anticipated by Foster (see 1899, Abstract No. 1938), with whose results they agree; light produces no hydrolysis in this case. T. H. P.

878. *Physico-Chemical Studies of Tin.* **E. Cohen** and **C. van Eijk.** (Zeitschr. Phys. Chem. 30. pp. 601–622, 1899.)—The crumbling of ordinary white tin into powdery grey tin was observed in 1851 by O. L. Erdmann in the case of some old organ-pipes containing 8·7 per cent. of lead, and again in 1869 by Fritzsche in the case of some blocks of pure tin which had been exposed to an intense cold during the preceding winter. Fritzsche showed that the change from grey to white tin was reversible, and could be made to proceed in either direction by heating or cooling. The grey tin has a much lower density than white tin, and when immersed in dilute potash, hydrochloric acid or sulphuric acid appears electronegative towards it.

By using a dilatometer the authors were able to locate the transition-point from grey tin to white tin, since the petroleum in the capillary began to sink when the temperature had been slowly raised to 30°. The position of the transition-point was determined exactly from the electromotive force of an element—grey tin | 10 per cent. solution of pink salt | white tin—which became zero at 20°. It was then found that the conversion of white tin into grey tin, which cannot readily be brought about even by cooling to −83°, can be easily effected by cooling to −15° if a few drops of the pink-salt solution are added to the tin-powder; the change from grey to white at temperatures only a few degrees above the transition-point also takes place quite readily

presence of a few drops of pink-salt. The determination of the transition-point shows that, except during a few warm days in summer, the whole of the world's tin supply is in a metastable condition, and tends slowly to crumble away to grey tin. Determinations of the velocity of change showed that the conversion of white tin to grey tin takes place most rapidly at about — 48° C.; grey tin can, however, be prepared in large quantities by mixing a large mass of tin-filings with a little grey tin, adding pink-salt solution and keeping at — 5° during eight days. T. M. L.

879. *New Type of Transition Element.* **E. Cohen.** (Zeitschr. Phys. Chem. 30. pp. 623–627, 1899; read before the Königl. Akad. der Wissenschaften zu Amsterdam. Sept. 30, 1899.)—The new type of transition-element is that made use of in the work described in the preceding Abstract, and consists of the combination: Metal M (stable α-modification) | dilute solution of a salt of the metal M | metal M (metastable β-modification).
T. M. L.

880. *Hydrolysis of Salt Solutions.* **L. Bruner.** (Zeitschr. Phys. Chem. 32. pp. 133–136, Feb. 6, 1900.)—The author gives the results of determinations of the hydrolytic dissociation of solutions of varying strengths of twenty-three chlorides, ten nitrates, and three sulphates, the optical sugar-inversion method of measurement being made use of. The following are the conclusions drawn: (1) The chlorides of the tetravalent metals are the most highly dissociated salts, stannic chloride, for example, being completely dissociated at the dilution $v = 8$. (2) After these come the salts of iron, aluminium, uranium, and beryllium, which mostly show considerable dissociation. (3) For other salt solutions the amount of dissociation is always much less than 1 per cent. No hydrolysis can be detected in solutions of ammonium, potassium, lithium, manganous, cobaltous, cerous, or erbium chloride, nor in silver, manganous or cobalt nitrate. For the chlorides of the alkaline earth metals, the percentages of dissociated salt lie between 0·02 and 0·07 per cent., and are hence too small to be reliable. (4) In the case of uranium, aluminium, and beryllium salts, the chlorides suffer the most and the sulphates the least hydrolysis, the nitrates being intermediate. The results of the author's work, which was originally published in Polish by the Warsaw Society for Promoting Trade and Industry (Wszechswiat, 1898. 23. 365), are in complete accord with those of Ley (Zeitschr. Phys. Chem. 30. 2. 218, 1899). T. H. P.

881. *Real and Apparent Freezing-point and Freezing-point Methods.* **M. Wildermann.** (Zeitschr. Phys. Chem. 30. pp. 577–585, 1899.)—The author gives a *résumé* of the modern theory of freezing-point determinations, which was founded by Nernst and Abegg, and has since been extended and worked out by himself. Having sketched the theory and given the various formulæ, the author proceeds to explain how these formulæ may be employed to calculate the error of any particular method. The object aimed at in freezing-point measurements is to bring the observed temperature of equilibrium, *i.e.*, the *apparent* freezing-point, as nearly as possible into coincidence with the *convergence-temperature*, *i.e.*, the temperature of radiation-equilibrium with the surroundings. In practice, exact coincidence cannot be attained, and so the author calculates what error is produced by a difference between these temperatures of 0·1° C. By "error" is understood here the difference between the observed temperature of equilibrium and the true freezing-point. He finds for his own method an error

0.00002° C., and for two other methods errors of 0·006°–0·012° and 0·004°. His conclusion is that for work with very dilute solutions, correct thermometry in the ordinary sense is not sufficient. Everything depends on the correct adjustment of the factors which determine the observed temperature-equilibrium. F. G. D.

882. *Carbon-consuming Batteries and their Possibilities.* **W. R. Cooper.** (Inst. Junior Engineers, Trans. 9. pp. 97–120, 1898–99.)—The author compares the efficiency of a steam-generating plant with a battery, and finds about 12 per cent. in the former and 73 per cent. in the latter case. It is shown that in everyday working the efficiency of the steam-plant will probably be nearer 6 per cent., owing to practical difficulties. There is thus seen to be a great opening for a battery which could transform the chemical energy of the system, carbon + oxygen, into electrical energy. The author then considers the theoretical conditions which a voltaic cell must fulfil, and emphasises the fact that for voltaic action the products of the chemical reaction must appear at separate points. From a consideration of the nature of carbon and its compounds, it is shown that the chief difficulties in constructing a carbon-consuming battery are: (1) Insoluble nature of carbon; (2) Scarcity of electrolytic carbon compounds; (3) Inability of carbon to act as an ion. Having shown that the Grove gas cell is commercially useless owing to the slow rate of absorption of the gases by the electrodes, the author goes on to consider the cells proposed by Borchers, Reed, Coehn, Jacques, and Blumenberg, and shows that none of these cells are really true voltaic combinations for transforming the chemical energy of the system carbon + oxygen (or carbon monoxide + oxygen) into electrical energy. They all fail to fulfil the fundamental conditions. F. G. D.

883. *Antimony Trichloride in Cryoscopy.* **S. Tolloczko.** (Zeitschr. Phys. Chem. 30. pp. 705–710, 1899; read before the Kaiserl. Akad. der Wissenschaften in Krakau, Nov. 6, 1899.)—In order to test the validity of Brühl's views concerning the causes of the dissociating power of solvents (1899, Abstract No. 861), the author has examined the cryoscopic behaviour of solutions of several organic and inorganic compounds in antimony trichloride. As the heat of fusion of this solvent is unknown, the mean experimental number, 184, is taken for the molecular depression of the freezing-point. Xylene, anthracene, diphenylmethane, acetophenone, and benzophenone show normal molecular weights; whilst, with potassium chloride and bromide, dissociation occurs to an extent which diminishes as the concentration increases. Antimony chloride, then, possesses dissociating power, as Brühl's theory would indicate.

For determining the molecular weight of organic substances this solvent is very convenient, as it has a very high molecular depression, and hence admits of the use of dilute solutions. T. H. P.

884. *Freezing-points of Solutions.* **E. H. Loomis.** (Phys. Rev. 9. pp. 257–287, 1899.)—The author shows that his cryoscopic method is exact. An error was discovered which was due to the fact that the thermometer when not in use was kept wholly packed in ice. Only the lower part of the thermometer should be so treated, the upper part being kept at the temperature of the room. The greater part of the paper contains results obtained with dilute aqueous solutions of non-electrolytes, including *n*-propyl alcohol, *n*-butyl alcohol, amyl alcohol, *glycerine*, acetone, dextrose, cane sugar, mannite, aniline, *methyl alcohol, ethyl alcohol* and ether. All these, except

the last three, have the same value for the molecular depression, viz., 1·86. The van't Hoff constant is 1·87, but this difference might be accounted for by a small error in the heat of fusion of ice. As the concentration of the solutions increases, the molecular depression varies. This is not surprising when it is remembered that the solute is assumed to occupy a volume equal to that of the solution, like an ideal gas. In the equation of van der Waals a correction is introduced so as to allow for the space taken up by the molecules themselves. A similar correction in the case of solutions may be effected by defining the concentration in terms of gramme-molecules per 1,000 c.c. of *solvent*, instead of in gramme-molecules per 1,000 c.c. of solution. Upon recalculating the depression on this basis the author finds that the molecular depression is constant in the case of methyl and ethyl alcohol, glycerine, dextrose, mannite, and chloral hydrate (limits generally 0·01 to 0·20 grammes per litre). Want of constancy in the case of methyl and ethyl alcohol and ether may possibly be due to evaporation from the solution. W. R. C.

885. *Application of the Phase Law to Alloys and Rocks.* **H. le Chatelier.** (Comptes Rendus, 130. pp. 85–87, Jan. 8, 1900.)—The author first enunciates the phase law in the form $v = n + p - r$, where $v =$ no. of degrees of freedom of system, $n =$ no. of independent components, $p =$ no. of variable physical parameters, and $r =$ no. of phases. If temperature be the only physical parameter which is variable, then $v = n + 1 - r$. If we now consider a mixture of solid bodies at ordinary temperatures, obtained by a series of reversible transformations (such as solidification by cooling, crystallisation from a solution, &c.), the result will be a stable solid mixture whose temperature may be varied within finite limits without any one of the phases necessarily disappearing. Hence $v = 1$ and therefore $n = r$. We thus arrive at the proposition : "The stable state of a solid mixture obtained in this way is such that the number of phases present is equal to the number of independent constituents."

As an example of this proposition the author considers the gradual cooling of melted cast iron. The following stages occur : (1) Liquid, $r = 1$, $v = 2$. Temperature and composition variable. (2) Liquid + graphite, $r = 2$, $v = 1$. Composition of liquid a function of the temperature. (3) Liquid + graphite + solid solution of carbon ; $r = 3$, $v = 0$. Temp. = circa 1,150°. (4) Graphite + solid solution ; $r = 2$, $v = 1$. Composition of solid solution a function of the temperature. (5) Graphite + solid solution + pure iron ; $r = 3$, $v = 0$. Temp. = circa 700. (6) Graphite + pure iron ; $r = 2$, $v = 1$. Variation of temperature ceases to affect the state of the system, which now cools down to ordinary temperature without further change.

[These considerations are quite analogous to those introduced by van't Hoff and Meyerhoffer in their treatment of paths and end-points of crystallisation.]

As a further example we have granite with the *three* independent constituents—silica, alumina, and potassium oxide—and the *three* phases—quartz, felspar, and mica. If for any such solid mixture $r > n$, then some of the successive changes have been *irreversible*, and the solid mixture will not be stable. The two principal causes operating to produce such unstable mixtures are rapid cooling and solidification in successive layers, whereby certai[n] parts become practically isolated. The author finally points out that in th[e] case of metallic alloys such unstable solid mixtures are characterised [b]y properties which vary greatly with the particular procedure followed in th[eir] preparation. F. G.

886. *Kinetics of Reactions with Secondary Action.* **R. Wegscheider.** (Zeitschr. Phys. Chem. 30. pp. 593–600, 1900.)—A secondary action (Nebenwirkung) is one in which the original substances forming the principal reaction are concerned, but suffer a different transformation to that of the principal reaction. A subsequent action (Folgewirkung) is one in which the products of the principal reaction react further. The author gives the differential equations for the case of secondary actions, and the solutions in certain cases. The mathematical reasoning does not admit of an abstract, but the following conclusions are arrived at: (1) If m reactions occur together, m differential equations are in general required to express the course of the action. The ratio of products formed in the different reactions is not independent of the time. (2) If in n of the reactions the same proportions of the reacting substances are involved, the number of differential equations is reduced to $m-(n-1)$. (3) If in two reactions the same proportions of the reacting substances are involved, the ratio of products formed in the two is independent of the time. The same is true if for any other reason (*e.g.*, appropriate catalytic action) the expressions for the velocities of two reactions differ only by a constant factor. And conversely such a constant ratio of products is a proof of the existence of a reaction with secondary actions of the properties stated. R. A. L.

887. *Ionisation Constants of Very Weak Acids.* **J. Walker** and **W. Cormack.** (Chem. Soc., Journ. 77 and 78. pp. 5–21, Jan., 1900.)—By means of a closed apparatus specially devised for use with solutions of gaseous substances, the authors have carefully determined the electrical conductivities of solutions of a number of compounds of an acid nature. Their results are shown in the following table, the first column of figures giving the ionisation constants, k, calculated by Ostwald's formula, and the second, the percentage ionisation in decinormal solution; the values for hydrochloric and acetic acids are added for comparison.

	$k \times 10^{10}$.	100 m.
Hydrochloric acid	...	91·4
Acetic acid	180,000	1·30
Carbonic acid	3,040	0·174
Hydrogen sulphide	570	0·075
Boric acid	17	0·013
Hydrocyanic acid	13	0·011
Phenol	1·3	0·0037

A single experiment with acetylene shows that its acid properties are very feeble, the dissociation constant being less than that of phenol. Although the values obtained by the authors for the conductivities and constants of the weakest acids are certainly too high, the errors are not great, as the numbers are in good agreement with the hydrolysis determinations of Shields (Phil. Mag. v. 35. p. 365, 1893). The bearing of the authors' results on those of previous observers is discussed in detail. T. H. P.

888. *Ionisation Constants of Weak Acids and the Hydrolysis of their Alkali Salts.* **J. Walker.** (Zeitschr. Phys. Chem. 32. pp. 137–141, Feb. 6, 1900.) —From the values obtained by Walker and Cormack (see preceding Abstract) for the ionisation constants of various weak acids, the author calculates the percentage of hydrolysed salt in 0·1-normal solutions of the acetate, bicarbonate, sulphydride, metaborate, cyanide, and phenolate of sodium. The numbers agree on the whole with those obtained by Shields (Zeitschr. Phys.

889. *Electrochemical Equivalents of Copper and Silver.* **T. W. Richards, E. Collins, and G. W. Heimrod.** (Amer. Acad., Proc. 35. pp. 123–150, 1899.) Metallic copper dissolves in an acid solution of copper sulphate, even when free from air and protected by an atmosphere of hydrogen, giving rise to cuprous sulphate ; a deficiency is thus caused in the deposit of metal which is proportional to the area of the plate, and can be corrected for by extrapolating to a plate of zero area. In a neutral solution, on the other hand, the values are too high, owing to the deposition of cuprous oxide on the kathode ; the solution employed must therefore be acid. By reducing the area of the kathode the error due to dissolution of the copper can be materially reduced, but if the current density becomes at all high, the weight of metal is reduced owing to the deposition of hydrogen in place of copper ; this effect is most pronounced in dilute solutions, which might otherwise be employed with advantage to reduce the error due to dissolution of copper.

The best values for the electrochemical equivalent of copper are obtained only when the following precautions are used : (1) The solution must be cooled with a freezing mixture ; (2) it must be acidified to prevent hydrolysis of the cuprous sulphate and precipitation of cuprous oxide on the kathode ; (3) it must be as dilute as is consistent with preventing the liberation of hydrogen ; (4) air must be excluded. By adopting these precautions and extrapolating to a plate of zero area the maximum atomic weight of copper has been found to be 63·563, taking that of silver as 107·93 and using the ordinary form of silver voltameter. Using a cupric solution already saturated with cuprous sulphate, higher values were obtained, viz., 63·573 at 0° and 63·615 at 60°.

The ordinary form of silver voltameter has been shown by a number of observers to give variable results owing to secondary actions, accompanied by the liberation of acid, at the anode. These sources of error are very largely eliminated by enclosing the anode in a porous pot instead of a filter-paper, and keeping the level of the liquid lower inside than outside the pot. Under these conditions the electrochemical equivalent of silver was found to be 0·0011173 grammes per ampere-second, and that of copper becomes 0·0003292 grammes per ampere second when the corrected value for silver is used ; hence also 96,610 coulombs correspond to one gramme-equivalent of an electrolyte. The atomic weight of copper, determined from the corrected electrochemical equivalent is shown to lie between 63·598 and 63·615, and agrees closely with the value 63·604 obtained by chemical methods.

The paper contains full references to the work of Foerster and Siedel, Kahle, Patterson, and Guthe, and other workers on the subject. T. M. L.

890. *Ozone by Electrolysis.* **G. Targetti.** (N. Cimento, 10. pp. 360–365, 1899.) The author gives results of a number of experiments made in order to determine the best conditions for the production of ozone by electrolysis. His conclusions are : (1) Lead is the best metal for the electrodes ; (2) the amount of ozone evolved per unit of energy expended is proportional to the current density at the anode ; (3) the best concentration for the sulphuric acid is that corresponding to a density of 22° Bé (1·180) ; (4) oxygen containing the same proportion of ozone is evolved, whether the voltameter is kept at $-2°$ or $+17°$; (5) a current of air injected into the liquid greatly increases the yield of ozone. Ozone cannot be produced economically by electrolysis, as by the expenditure of 1 H.P.-hour, about 2·78 grammes c ozone are obtained, whilst Andreoli guarantees 100 grammes, and by usin high frequencies Otto has obtained as much as 154·9 grammes for the san amount of energy. T. H.

891. *Deposition of Silver-Cadmium Alloys.* **S. Cowper-Coles.** (Indus. and Iron, 26. pp. 69, 85, 102–104 and 164–165, 1899.)—A serial—incomplete—relating to the influence of current density, strength of electrolyte, ratio of metallic salts in solution, and presence of extraneous salts, upon the deposits of silver and cadmium obtained at the kathode by electrolysis of a solution of the double cyanide of these two metals. After an historical introduction, very full details are given of the experiments made by the author bearing upon the above points; and numerous tables and diagrams are printed containing the results. The articles are not adapted for useful abstraction, and the originals should be referred to by those interested in the subject. J. B. C. K.

892. *Electrochemical Behaviour of Silver Fluoride and of Fluorine.* **R. Abegg** and **C. Immerwahr.** (Zeitschr. Phys. Chem. 32. pp. 142–144, Feb. 6, 1900.)—The authors have determined the molecular conductivities, in ohm^{-1} $cm.^{-1}$ units, of solutions of silver fluoride. In the more concentrated solutions, this salt shows almost exactly the same dissociation as silver nitrate, whilst for dilutions greater than about 0·00516 normal, the values obtained for the molecular conductivity exceed the value, 0·1016, indicated by Kohlrausch and Holborn (Leitvermögen der Elektrolyte, p. 202) for solutions of infinite dilution; in these dilute solutions, then, hydrolysis takes place, owing to the slight electro-affinity of the silver ion. This high degree of dissociation of silver fluoride shows that the fluorine ions are possessed of very great electro-affinity, a conclusion confirmed by the value, 1·75 volt, of the decomposition E.M.F. of fluorine.

The authors find that perfectly neutral solutions of silver fluoride dissolve an appreciable quantity of silver oxide, and are then alkaline to litmus, although a saturated aqueous solution of silver oxide has a neutral reaction. This increase in solubility of silver oxide in water containing another silver ion is due to the formation of a complex ion of the probable composition Ag_2AgOH. T. H. P.

893. *Villon Process for Manufacturing Alcohol.* (Elect. Rev. N.Y. 35. p. 375, 1899.)—The Villon process for the manufacture of ethyl alcohol is now in operation in Russia, and the product is being used as a fuel in motor vehicles. The raw materials of the process are limestone and coke. These are ground, and heated together in an electric furnace in order to produce calcium carbide. The carbide is then decomposed with water in the usual manner, and the resulting acetylene gas is converted into ethylene gas by allowing it to pass through a solution of chromium and ammonium sulphates, maintained at a temperature of 40° C. The ethylene gas is then absorbed in sulphuric acid, and the hydrogen-ethyl-sulphate obtained in this way is distilled after the addition of water. The distillate is condensed and is ethyl-alcohol of a very pure character. It is stated that with carbide at $20 per ton, the cost of the alcohol is 8 cents per gallon. Figures showing the apparatus used in this method of manufacture are given. J. B. C. K.

REFERENCES.

894. *Contact* v. *Chemical Theory.* (Elect. Rev. 45. pp. 1031–1034, 1899.)—Discussion of the theory of the Volta effect. W. R. C.

895. *Ionic Velocities.* **O. Masson.** (Roy. Soc., Phil. Trans. 192. pp. 331–350, 1899.)—A paper similar to that referred to in Abstract No. 258 (1900). W. R. C.

STEAM PLANT, GAS AND OIL ENGINES.

896. *Advantages of Superheating and the Superheater of Liège University.* **G. Duchesne.** (Amer. Electn. 12. pp. 75–76, Feb., 1900.)—A few authentic cases are cited of the increased economy due to superheating, and a description of the Liege superheater is given together with the results of some tests showing a saving due to superheating of 11·25 per cent. on an installation not designed to obtain economy. J. T. R.

897. *Dellwik-Fleischer Water-Gas.* (Engineering, 69. pp. 118–119, Jan. 26, 1900.)—All practical water-gas processes are intermittent, and consist in heating up the fuel by means of an air-blast, followed by the decomposition of steam by contact with the incandescent carbon thus heated. The older water-gas generators produce generator gas ($CO + N_2$) during the heating periods, which occupy about forty-five minutes of each hour, leaving only fifteen minutes for the water-gas production. The Dellwik-Fleischer water-gas generators are heated about ten minutes, giving only waste gas ($CO_2 + N_2$), leaving fifty minutes of the hour for the water-gas production, so that the yield of gas is more than double that obtained by the older processes. Vivian B. Lewes found by experiment that one ton of coke, containing 87·56 per cent., or 1961·8 lbs. of carbon, yielded 77,241 cubic feet of Dellwik water-gas, having a gross calorific value in Junker's calorimeter of 304 B.Th.U. per cubic foot. Hence the calorific value of this water-gas from a ton of coke was over 82 per cent. of the heating value of the total coke used in both generator and steam boiler, taking 20 per cent. of the coke as used for raising steam. Every 1 lb. of carbon yielded nearly 40 cubic feet of this water-gas composed of 51 per cent. hydrogen, 41 per cent. carbonic oxide, 0·5 per cent. of marsh-gas, 4·5 per cent. carbonic acid, and 3 per cent. nitrogen. During the last two years Dellwik water-gas has been used in the iron industry for firing the welding furnaces, and for tempering and annealing. On the Continent this water-gas is also used to increase the capacity of coal-gas works. The mixture of coal-gas and water-gas is enriched by benzol to the desired candle-power. The supply of benzol is steadily increasing from by-product coke ovens, and at the present time benzol-carburetted water-gas, as admixture to coal-gas, is produced in Germany at a lower cost than is possible with water-gas enriched by oil. As an enricher benzol is likely to supplant petroleum owing to the rise in the price of the latter.

Dellwik water-gas is one of the cheapest fuels for producing power by means of gas engines. One large gas engine firm is prepared to guarantee a consumption of 30·5 cubic feet of this water-gas per H.P. hour. With coke at 9s. per ton the gas costs only about 8d. per 1,000 cubic feet, and this makes the cost per hour of a H.P. about $\frac{1}{10}$d. for fuel. W. R.

898. *Tests of a Westinghouse Gas Engine.* **C. H. Robertson.** (Engineering, 69. pp. 135–140, Jan. 26, 1900. Paper read before the American Society of Mechanical Engineers.)—The author gives (1) a description with drawings of a 125 H.P. Westinghouse gas engine, using natural gas and driving a 60-kilowatt two-phase alternator; and (2) results of a five hours' test, under service conditions, with measurements of the power developed and ga

consumed, at Lafayette, Ind., in March, 1899. The three vertical cylinders 13 inches diameter by 14 inches stroke have a clearance of 21·28, and 21·59 per cent. The gas and air pass through a mixing-valve chamber, and the speed is controlled by throttling the charge. To start the engine compressed air is stored in a steel cylinder at 160 lbs. gauge pressure. One cylinder is converted into a compressed-air engine until speed is got up to slightly compress and fire a charge in the other cylinders by electric igniters. A gasoline vapour generator is installed to provide against interruption of the gas supply.

Chemical analysis of the natural gas used as fuel gave the percentage of methane 92, hydrogen 0·6, hydrocarbon 0·5, and carbon monoxide 0·55, with carbon dioxide 1·8, nitrogen 3·8, and oxygen 0·7. The exhaust pipe was red-hot, and its temperature by copper ball calorimeter was about 1,200° F. "Back-firing" or ignition of the incoming charge in the distribution pipe took place during the test. The highest speed in r.p.m. was 280, the lowest 265, and the average 270·86; or a variation of 5·5 per cent. The average I.H.P. was calculated from observations every five minutes. The efficiency of the alternator was known, and hence the B.H.P. of the engine. The highest mechanical efficiency was 84·6 per cent.

The tests showed the lowest and highest gas consumption in cubic feet per hour (reduced to 14·7 lbs. per square inch and 62° F.) to be 11·87 to 18·42 per I.H.P., 14·71 to 29·65, per B.H.P., and 16·52 to 40·59 per electrical H.P. By plotting the total gas per hour and the different I.H.P's. in each case a straight line can be drawn to represent the average gas consumption at different loads like Willans' law for steam engines, namely, that the total steam per hour plotted against the I.H.P. is a straight line.

The conclusions are: (1) That the proportion of gas to air is a very important factor in fuel economy; (2) that one test at a light and one at a heavy load would give the line, from which a prediction could be made of the gas consumption under intermediate loads; (3) these hold for the fuel consumption per B.H.P. hour and per electrical H.P. hour. The best thermal efficiency of the engine, that is, the B.Th.U. equivalent to the B.H.P., divided by the B.Th.U. in the gas consumed was 17·3 per cent.—not high for a gas engine. The heat distribution is shown by the following table:—

Time.	B.Th.U. supplied per hour.	Per cent. converted into indicated work.	Per cent. absorbed by jacket.	Per cent. lost by exhaust.	B.Th.U. per I.H.P. per minute.
1st hour.	1,574,200	17·9	25·2	56·9	237·5
2nd "	1,674,880	16·3	21·0	62·8	264·7
3rd "	1,169,000	20·7	30·2	48·9	294·2
4th "	1,096,600	20·2	36·9	42·7	211·1
5th "	828,000	16·0	50·3	43·9	259·3

The poor result during the first and second hour is due to the improper mixture of gas to air in the proportion of 1 : 11, then the ratio was changed to 1 : 12. The lowest consumption of gas per I.H.P. per hour was 11·87 cubic feet, giving 11,870 B.Th.U. at a cost of \$0·07 (3½d.) per thousand cubic feet.

The main results and features of the trial are shown graphically. W. R.

899. ***Liverpool Trials of Motor Vehicles; Judges' Report.*** (Automotor Journal, 4. pp. 143–153, Jan., 1900.)—This is an abstract of the report of the

trials made at and near Liverpool in October, 1899, of six different heavy motor vehicles under the auspices of the Liverpool branch of the Automobile Club of Great Britain. There were entered for the trials eleven vehicles, and of these the six whose makers' names are given in the accompanying Table I

TABLE I.

Summary of Particulars.	Thornycroft No. 1.	Thornycroft No. 2.	Coulthard No. 3.	Leyland No. 4.	Clarkson & Capel No. 5.	Bayley No. 6.
Total moving weight laden and fully provisioned, including attendants—tons...	7·465	8·420 3·182	4·998	7·753	6·765	7·282
Mean moving weight laden and fully provisioned, including atteudants—tons...	7·235	8·094 3·182	4·886	7·636	6·676	7·129
Mean tare, not including attendants —tons.................	3·582	4·004 0·737	2·524	3·141	3·359	3·469
Load carried—tons...	3·73	4·09 2·56	2·32	4·44	3·35	3·67
Ratio of mean tare to load....................	0·96	0·71	1·09	0·71	1·00	0·95
Declared B.H.P.......	35	40	14	14	14	22
Mean tare per declared B.H.P—cwts.	2·04	2·37	3·60	4·48	4·80	3·16
Mean total moving weight per declared B.H.P.—cwts.	4·14	5·46	6·98	10·88	9·54	6·48

appeared and went through the trials. This table is an abstract of the whole of the most important results obtained during tests which included the transport of heavy loads over various good and very bad roads and hills, and over considerable distances. Table II. gives a summary of those figures which relate to cost per ton mile of goods carried. The tables together provide information which is a key to the whole report, all the vehicles being steam propelled.

TABLE II.—SUMMARY OF FACTORS AFFECTING THE COSTS PER NET TON-MILE.

Vehicle.	Prime Cost.	Load Carried.	Commercial Speed. Miles per Hour.	Fuel Consumption per Vehicle-mile.	Fuel Consumption per Ton-mile of Load.	Water Consumption per Vehicle-mile.	Water Consumption per Ton-mile of Load.	Cost of Motive Power per Ton-mile of Load.	Cost of Attendants per Ton-mile of Load.
	£	tons.				galls.	galls.	d.	d.
Thornycroft	590	3·73	5·31	8·88 lbs. coal.	2·38 lbs. coal.	7·15	1·88	0·27	0·44
Thornycroft	640	6·65	5·67	12·46 lbs. coal.	1·87 lbs. coal.	9·81	1·33	0·22	0·36
Coulthard...	400	2·32	4·78	...	...	...	...	...	...
Leyland ...	450	4·44	5·02	0·539 gall. oil.	0·121 gall. oil.	4·00	0·91	0·62 [1]	0·38
Clarkson ...	450	3·35	4·94	0·724 gall. oil.	0·216 gall. oil.	2·13	0·64	1·09	0·52
Bayley	600	3·67	4·93	6·76 lbs. coke.	1·84 lbs. coke.	4·65	1·27	0·13	0·65

[1] Last year's cost was 0·53d., kerosene being then at 4d. per gallon. If kerosene had been at 5d. pe gallon as it is now, the cost for last year would have been 0·66d.

W. W. B.

60-kilo. New Carburettors. (Automotor Journal, 4. pp. 209–210, Feb., 1900.)
service *ed description* with sectional drawings of three new petrol carburetto

for oil motors. Parsons' carburettor contains wicks of a porous fabric, which are kept partially saturated with petrol and through which air is drawn. Provision is made for the variably controlled admission of fresh air which mixes with the carburetted air before passing to the motor cylinder. It is stated to be a somewhat complicated apparatus. The Le Blou and the Abeille carburettors are both modifications of the well-known pulverising constant level type, but are intended to produce a more homogeneous mixture of air and petrol and to be more accurately adjusted. A. G. N.

901. *French Motor Trials.* (Automotor Journal, 4. pp. 202–203, Feb., 1900.) —The results are given of tests carried out by *La Locomotion Automobile* to determine the actual power of oil motors as attached to motor-cars. Two tables of results are included. The first refers to the motors only—make, type of carburettor, cylinder dimensions, brake test weights, speed, and B.H.P. The second refers to the cars complete—weight on driving wheels, speed, brake test weights, B.H.P. at driving wheels. The cars were fixed in such a manner that the driving wheels rested on a roller, which they caused to revolve, and which was fitted with a power-measuring brake. Very few of the motors in table (1) correspond with vehicles in table (2), so that the efficiencies of the gearing can be only obtained very approximately. An increase of output appears to accompany the use of a spraying carburettor as compared with a mixing (gasifying) one. Their relative efficiency is not shown. The use of an exhaust silencer is shown to considerably reduce the output of the motors. The B.H.P. of the motors tested varies from 1·32 to 10·5, and the weight on the driving wheels of the cars tested varies from 200 to 500 kilogrammes. The motor speeds vary from 623 to 2,057 r.p.m., and their dimensions from double cylinder 110 mm. bore, 160 mm. stroke, to single cylinder 66 mm. bore, 70 mm. stroke. A. G. N.

902. *Heavy Motor Waggons for Liverpool Traffic.* **A. Musker.** (Automotor Journal, 4. pp. 153–159, Jan., 1900. Paper read before the Liverpool Engineering Society on Dec. 13, 1899.)—The author describes the main features of a lorry and its mechanism designed by his firm for heavy work, namely, to carry 5 or 6 tons on a tare weight of 3 tons. One main feature of the design is an arrangement by which the lorry platform is clear from end to end of all obstructions in the form of either boiler or machinery. An experimental lorry has been made driven by a four-cylinder single-acting high-pressure engine supplied with steam by a boiler consisting of three coils of steel tube acting on the Serpollet system. The boiler is fired by an oil burner, and the oil and air and the water supply are automatically controlled with reference to steam pressure and with relation to each other. This is done by one combined auxiliary fan engine pump. The transmission gear consists of a spur gear driven countershaft, carrying sprocket wheels for chains which drive the road wheels. A new form of oil fuel burner is described but not shown. A useful table is given with the paper, comprising a list of twenty-four different kinds of freight with the space occupied on a lorry platform, number of packages, and total load. W. W. B.

903. *Serpollet Superheated Steam Motor.* (Automotor Journal, 4. pp. 212–214, Feb., 1900.)—This article describes the recent form of high-speed engine single acting, designed for use with high pressure and highly superheated steam by Serpollet. A feature of the engine, which has two opposite

cylinders, connected by rods to a single crank, is the use for steam admission of small mushroom valves actuated as they are in gas engines, and having rods passing through long guide bosses without any packing; the rods are actuated by rotating cams which may be placed at either end of the shaft carrying them so as to present cam projections which are in the necessary relative positions for running the engine in either direction. Exhaust is by outlet ports uncovered by the pistons at the end of the stroke. W. W. B.

904. *Recent Experiences with Steam Vehicles.* **J. I. Thornycroft.** (Feilden, 4. pp. 429–441, 1899.)—This paper commences with a reference to the present legal restrictions on the use of the heavier kinds of motor vehicles under the Locomotive and Highways Act of 1896, and points out that the regulation relating to the deduction of the weight of the fuel and water from the total weight of the vehicle acts very unfavourably against the steam and oil vehicles as compared with the electrical vehicles, the weight of the accumulators in which is deducted from the total weight of the vehicle though it may be as much as half the whole weight. The author points out that to put the steam vehicles on the same basis, the boiler and its water, which corresponds with the battery and its electrolite, should be deducted. He urges, however, that instead of fixing arbitrarily upon a definite tare weight, a maximum load per inch width of tyre would provide better against undue damage to roads; though it would indeed be better to remove all such restrictions, thus placing English makers and users in the position of those in France. His experience leads him to the opinion that a quite satisfactory steam-driven vehicle for 3 tons can be built to a tare of 4 tons and maintain a "commercial speed" (average speed including stoppages) of six miles per hour. In the remainder of the paper the author describes eight different forms of Thornycroft heavy steam vehicles, illustrated by photographs, including those of the most recent and highly successful drays, all of which are driven by gearing instead of by the chains formerly used. The paper concludes by a further expression of opinion as to the necessity for raising the 3 ton tare limit, and concerning the assured ultimate success of the modern high-road motor waggon. W. W. B.

905. *Simpson-Bodman Steam Lorry.* (Indus. and Iron, 28. pp. 85–87, Jan. 19, 1900.)—Describes the construction and working system of this heavy type of motor-car. It weighs nearly 3 tons, can carry 3¼ tons load, and has an area of 78 square feet for carrying goods. Two independent engines are used, each capable of giving 8½ B.H.P. at 500 revolutions per minute with 100 lbs. steam pressure. Three sets of pinions, giving ratios of 10, 18, and 24, are provided between the engine shafts and the driving wheels of the car; when the car is at rest either set of pinions can be connected for use. The steam generator is built up of indented weldless steel tubes into which the water is forced in accordance with the pressure required. It is intended to allow the boiler to be dry when any long stops are required, a hand pump being provided for restarting the system. The driver normally controls the propelling mechanism by varying the water pump feed. Working steam pressure vari from 100 lbs. to 250 lbs. per square inch, but the temperature of the tubes usually 600° to 1,000° F. A steam drum is provided, and through this passes feed water heater. The exhaust steam from the engines is first passed into silencing chamber and is then superheated by the boiler furnace and ul mately passed in an invisible form to the atmosphere through a nozzle whi creates a draught for the fire. A. G.

[redacted]

906. *Automobiles.* **Cuénot** and **Mesnager.** (Écl. Électr. 21. pp. 420–423, 1899. Paper read before the Assoc. Française at Boulogne.)—After giving some historical notes, the authors remark that France is ahead of the world in automobilism owing to liberal laws which make no limit of weight, or width, or speed under 30 kms. per hour, provided certain tests are passed as to brake, steering, and the driver's capabilities. The total tractive pull on an average road is a fraction of the weight given by $0{\cdot}033 + 0{\cdot}0006\,V$ on solid rubber tyres, and $0{\cdot}025 + 0{\cdot}0004\,V$ on pneumatic tyres (where V is velocity in kms. per hour). The total weight in kgms. of any automobile ready to travel for H hours is as follows, per H.P. delivered to the wheels :—

Motor "Field"	$85 + 33H$
Motor with water-tube boiler	$67 + 22H$
"Serpollet" motor with coke............	$92 + 18H$
" " " petrol	$83 + 11H$
Petrol explosion engine	$67 + 0{\cdot}83H$
Electric motor and accumulators	$66 + 49H$

M. O'G.

907. *Motor-Cars.* (Automotor Journal, 4. pp. 173–175, Jan., 1900. Excerpt of a paper by **A. Craig** before the Cycle Engineers Inst., Coventry, Dec. 14, 1899.)—Electric ignition is preferred to all others. De Dion's mechanical trembler coil, and Simms' magneto generator are described.

Surface carburettors are protected from explosion by fine wire gauze between the petrol and the engine. Preference is given to the method of injecting the exact portion of oil required into the air which is entering the cylinder. A gradually variable gear without slipping is being attempted, (1) by taper cone pulleys with belt; (2) expanding pulley; (3) conveying the motion from the engine to the road wheels by an intermittent feed. M. O'G.

REFERENCES.

908. *Progress of Steam Engine.* **R. H. Thurston.** (Cassier, 17. pp. 191–199, Jan., 1900.)—An historical article, dealing with the progress of the steam engine. It contains curves showing the rate of change in ordinary practice as regards piston speeds, steam pressures, efficiencies, &c., throughout the century.

909. *Large Electric Lighting Engines.* **R. D. Summerfield.** (Elect. Engin. 25. pp. 6–7, Jan. 5, 1900.)

910. *Valve Motions of Engines.* **J. Perry.** (Nature, 61. pp. 152–153, 1899.)—Description of a geometrical construction invented by J. Harrison to show the relative positions of piston and valve. J. T. R.

911. *Oil Engines and Motor-Cars.* **A. G. New.** (Engineer, 89. pp. 1–2, Jan. 5, and pp. 29–30, Jan. 12, 1900.)

GENERAL ELECTRICAL ENGINEERING.

912. *Harris Watt-hour Meter.* (Elect. World and Engineer, 35. pp. 188–189, Feb. 3, 1900.)—The meter consists of four parts: An electro-dynamometer, of which the fixed coil takes the main current, and the movable the shunt current; a clockwork mechanism arranged to run for a definite short time; a "recording" cylinder rotated by the armature of an electromagnet in shunt across the mains, its circuit being closed every time the clockwork runs down and the armature at the same time rewinding the clock-spring; and an integrating train driven by a cylinder parallel to the recording cylinder. The recording cylinder drives this through a small roller attached to an arm on the movable coil of the dynamometer, the roller taking up some position between the ends of the cylinder, corresponding to the currents passing through the dynamometer. The recording cylinder has a wedge-shaped portion cut down which does not gear with the integrating cylinder through the roller, so that when the roller is at one end, corresponding to full load, the cylinders are in gear throughout the revolution, while at the other end, corresponding to no load, they do not gear at all.

The movement of the integrating cylinder is thus proportional to the deviation of the dynamometer coil, which is in turn proportional to the power. G. H. B.

913. *Fusible Cut-outs.* **B. H. Glover.** (Street Rly. Journ. 15. pp. 888–889, 1899. Paper read before the Chicago Electrical Association, Nov. 17, 1899.)—A cut-out consists of three principal parts: (*a*) The base and its cover; (*b*) the terminals; and (*c*) the fuse. The base should be well glazed porcelain and a cover for the base should always be used. The terminals should not be too near to each other. Careful experiments show that the best lengths of fuse are as follows:—

For 3 to 5 amperes	2·5 inches
For 10 to 15 amperes	3·5 „
For 20 amperes	4 „

and for each additional 5 amperes an increase of 0·5 inch in the length. For sudden heavy overloads a multiple fuse of several small wires is much more sensitive than one large one of the same capacity, and a thin, flat ribbon is better than a round fuse. W. G. R.

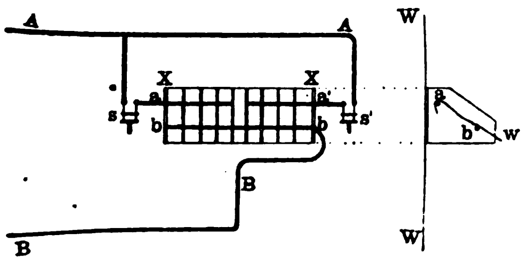
914. *Submarine Cable Breaks near previous Repairs.* **A. Gray.** (Inst. Civ. Engin., Proc. 138. pp. 350–352, 1899.)—After a repair, the dragged portion of cable remains in tension owing to the elasticity of the material and the absence of slack. Corrosion (probably due to abrasions in dragging) starts, and rupture results. M. O'

915. *Arched Cement Cable Conduits.* **C. H. Sewall.** (West. Electn. pp. 280–281, 1899. Paper read before the Chicago Electrical Associati Oct. 6, 1899.)—A single subway in the middle of a street is impractica because of its excessive cost, and because it requires connection under ets to the private lines, and so does not do away with cutting up

repairing streets. A draw-in system made by standing thin arches of cement without any bottom on a 3-inch cement floor is recommended. The arches are only $\frac{3}{16}$ inch thick on a wire gauze support, and the whole is surrounded in concrete, which sets to the cement arch.

Two hundred pairs of telephone paper cables are now made into a cable $1\frac{1}{2}$ inches over the lead; and three No. 0000 wires for a working pressure (three-phase) of 11,000 volts are made into a cable slightly more than 2 inches diameter. M. O'G.

916. *Simple Lightning Arrester.* **A. E. Kennelly.** (Amer. Electn. 11. p. 572, 1899.)—A simple and convenient form of lightning arrester has been designed by W. T. Cooke of Louisville, Ky., for use in central stations. The arrester is shown in front elevation and vertical section in the figure. Upon the wall, W W, of the station, near the switchboard, is a box, X X, with nine vertical partitions, each lined with asbestos paper. Into this box pass three copper rods *a*, *a'*, and *b*. The two former are connected through



switches, *s*, *s'*, with a heavy copper conductor leading directly to the positive 'bus bar of the switchboard. The lower rod, *b b*, is connected directly to the negative 'bus bar by a copper conductor without any switch. In any partition of the box a No. 16 double cotton-covered copper wire is hung. The upper end of the wire is bared and is hooked around the rod *a*, while the lower end is left covered and is allowed to rest by its weight on the ground rod *b*. The cotton covering will stand the 550 volts of the dynamos, but gives way under the pressure of a lightning discharge. W. G. R.

917. *Silicium Bronze and Aluminium Alloy for Wires.* **Massin.** (Écl. Électr. 22. pp. 140–141, Jan. 27, 1900. Annales télégraphiques, 25. pp. 200–204.)—This is an investigation of the qualities of the above alloys for use for overhead wires. The percentage compositions are not given. The densities are as 8·9 to 2·8, the breaking strains 75 and 28 kilos. per square mm., the conductivities as 41 to 48, and prices per kilogr. 2·85 fr. and 5·00 fr. respectively. Aluminium bronze, as well as aluminium, is more readily attacked than is generally supposed. Acid tests are described. The author finds that the aluminium alloy has larger coefficients of dilatation and elasticity than silicium bronze, and is consequently less suitable for use where strains and dips due to fluctuations of temperature have to be considered. The relative corrodibility is also a disadvantage. But, as has been stated above, the composition of the alloy is not given. E. O. W.

918. *Electric Welding.* **H. Lemp.** (Elektrochem. Ztschr. 6. pp. 159–169, 1899.)—The author first describes early methods of electric arc welding, in which the heat is obtained from an arc, and is very intense and localised.

Only a small surface of metal can be treated, and it is very liable to overheating. This is avoided in the method of welding introduced by Elihu Thompson, in which a very large current at a low voltage is passed through the metal, which is thus uniformly and intensely heated, owing simply to its ohmic resistance. The apparatus required is described and illustrated. The action of the alternate current transformer is explained on the analogy of friction wheels of different diameters. Details of the consumption of energy are given, showing the high efficiency of electric heating as compared to forge heating. The possible sources of energy and the various industrial applications of the process are described, including wire-making, welding on spokes of iron wheels, welding and bending pipes, and welding rail-joints. (See 1899, Abstract No. 1989.) L. B.

919. *Electricity in Gasworks.* **H. G. Field.** (Amer. Electn. 11. p. 578, 1899. From "The Technic.")—The Detroit City Gas Company has installed at its works a small electric lighting plant for the purpose of lighting certain rooms of the works where, owing to the inflammable and explosive nature of the atmosphere, naked lights are out of the question. An illustrated description is given of an apparatus for recording or indicating the gas pressure as measured either anywhere on the premises or at any distant point. It consists of a small gas-holder, to the bell of which is attached a contact arm sliding over a set of studs. Between the studs are resistance coils, through which a certain constant current is passed. The potential difference between the contact arm and one of the extreme studs is proportional to the height of the bell, that is, to the gas pressure. This potential difference can of course be tapped off to a number of recorders or indicators at any distance. E. D. P.

920. *Electrical Heating.* (Elect. Rev. 45. pp. 954–955, 1001–1002, 1899.)—Electrical heating for certain purposes is undoubtedly expensive and extravagant, but there are many purposes also to which it can be applied where electricity will be found cheaper than other methods. The points to be considered, when comparing electric heaters with others, are given. The everyday uses to which electrical heating can be applied with advantage are considered, such as: (1) Flat-irons for laundry purposes; (2) rolls for laundry work; (3) goffering-iron heaters for laundries, dye-works, &c.; (4) hot-plates and glue-pots for wood-workers' shops; (5) hot-plates and stoves for lacquering purposes; and (6) goose irons for tailors. The advantages of electricity for use in all these cases are given in detail; the chief points being—cleanliness, fire-risks, efficiency, regulation of temperature, and quantity of work turned out.

For cooking purposes the use of electricity will not cost an excessive amount if current can be purchased at 1d. or 1½d. per unit, and if some other means is provided for heating the usual large quantity of water required for domestic purposes. Electrical radiators for small rooms and for intermittent heating, even when supplied from central stations, will compare favourably with other forms of heating. With rooms over 5,000 cubic feet in size, and in rooms where continuous heating is required, electrical heating becomes too expensive. The average power required for heating a room is about 500 watts per 1,000 cubic feet of volume; and during the coldest weather this power will be required for two or three hours to raise the room temperature to about 65° F. The power may afterwards be reduced to about ¼ or ⅓. The best design of radiator is one which has a free draught and circulation of air through it. The first cost of radiators per 100 cubic feet of room

volume is given as: 6s. for rooms up to 1,000 cubic feet in volume, 4s. 6d. for rooms up to 2,500 cubic feet in volume, and 8s. 6d. for rooms up to 5,000 cubic feet in volume.

It may be taken as a general rule that, if the degree of temperature required for an operation exceeds 500° F., there will be difficulty in making electrical heating apparatus durable and satisfactory for general working.

E. D. P.

921. *Paris Electric Fire Engine.* **J. Reyval.** (Écl. Électr. 20. pp. 456–458, 1899.)—The author describes and illustrates this car which, so far, has been successful. The weight of accumulators is 520 kgs. M. O'G.

922. *A 35-ton Electric Travelling Crane.* (Écl. Électr. 21. pp. 389–391, 1899. Génie Civil, xxxv. p. 408, Oct. 21, 1899; from the Zeitschrift des Vereines Deutscher Ingenieure.)—A description and drawing of a heavy overhead 3-motor traveller, having a span of 16 metres in a boiler shop. The 15 H.P. hoisting series motor raises loads of 20 to 35 tons through 1·8 metres per minute, and higher loads at 2·7 m. per minute. The bridge is travelled at 40 m. per minute by a 10 H.P. series motor carried at the centre, and the carriage at 15 m. per minute by a 5 H.P. motor. An electric brake is automatically applied when the motor is stopped, and removed on starting up. The hook is double; it turns on ball bearings and is carried by three chains.

E. H. C.-H.

923. *Electric Travelling Cranes.* (Engineering, 69. pp. 13–15, Jan. 5, 1900.) —The most advanced practice in overhead travellers is to use a separate reversing motor for each motion; the paper describes and illustrates a 50-ton crane so constructed by J. Adamson & Co., of Hyde, Cheshire. The crane has four motors to drive the main barrel, the light barrel, the longitudinal motion, and the transverse motion respectively, with current at 220 volts. The main lifting speed is 4 feet per minute, the lifting barrel being 2 ft. 6 in. diameter, the corresponding motor running at 400 r.p.m., and there being three intermediate shafts between the motor and the barrel. The light lift is intended for loads up to 5 tons, the speed of lifting is 15 feet per minute and the speed of the motor 300 r.p.m. The speed is reduced at two steps by a worm gear and a pair of spur-wheels, the worm gear running in an oil bath. Both lifting drums are controlled by electric brakes. The brake wheel is pressed on by shoes applied by springs and released by an electromagnet which is energised when the current is directed to the corresponding motor. Should the current fail from any cause the brake goes on immediately and holds the load; on the other hand, immediately the crane is set to lift or lower, the brake is taken off. Should the load in falling drive the motor too rapidly, the back electromotive force reduces the current and the brake goes on of itself. The longitudinal travel of the crane takes place at a speed of 80 feet per minute, the speed of the motor is 300 r.p.m., and the reduction is effected in two stages. The transverse motion is at 40 feet per minute, and the motor runs at 500 r.p.m. The power absorbed by the motors when the crane is fully loaded is as follows: Main hoist, 25 B.H.P.; auxiliary hoist, 12 B.H.P.; traversing, 7 B.H.P.; longitudinal travel, 5 B.H.P. Curves are given showing the efficiency of the main and auxiliary hoisting gears at various loads. At 30 tons' load the efficiency of the main hoisting gear attains its maximum value of 68 per cent.; the efficiency falls to 56 per cent. for the full working load, 50 tons. The maximum efficiency of the auxiliary hoisting gear is 55 per cent., the corresponding load being 21 tons. A. S.

924. *Modern Mine Haulage Practice.* **H. K. Myers.** (Eng. Club Phil., Proc. 16. pp. 221–237. Discussion, pp. 237–239, 1899.)—This paper deals with the applications of locomotive power to haulage in mines, describing steam locomotives, compressed air locomotives, and lastly electric locomotives. Some striking figures as to the mileage of underground haulage ways and haulage miles per annum in some mines are given. It is estimated in the United States there are 50,000 miles of mine track utilising 100,000 mules, whose average life is only four years, the haulage costing 15 cents (7½ pence) per ton mile. Descriptions of the various locomotives and their performance are given, among others of electric locomotives by the Balmin-Westinghouse Co., by the General Electric Co., and others. One of these machines in practice is found to replace 24 mules and 12 men, saving $8,000 (£1,600) per annum. Ll. B. A.

925. *Electrically-driven Jacks.* (Elect. Rev. 46. p. 345, March 2, 1900.)—In the locomotive works at Nippes, in Germany, each 12-ton jack was manned by five men ; to raise a four-axle locomotive required 21 men for the four jacks. The average time for the lifting was 45 minutes and for the lowering about 30 minutes. In consequence of the variations in the time for each lift, depending on the willingness of the workmen, mechanical power for the operation of the jacks was introduced. Rope driving was tried and discarded. Compressed air and electrical power were both available at the works and were both tried. In comparison with the electrical gear the compressed air gear was complicated, and the cost of the electrical energy consumed was less than the cost of the compressed air used.

The electric motor used is mounted on a small car, the two jacks at one side of the locomotive are connected to the motor by solid spindles sliding in a hollow shaft on the feather and groove principle, a Hooke's joint being introduced to compensate for inequalities of level. The other two jacks are driven by chain gearing. The motor is of 5 H.P., and by means of main and shunt-circuit resistances has a range of speed from 300 to 1,035 r.p.m. Absolute evenness of lift by each jack is ensured in this way, and a considerable saving in time and labour is effected. The time occupied in raising a locomotive is 12 minutes, the lowering taking about the same time. At 110 volts a current of 35 to 38 amperes is required for raising and 20 to 25 amperes for lowering. The labour, including the shifting of the motor, can be supplied by two men.

Taking wages at 5d. per hour and electric energy at 2d. per kw. hour, the cost for hand manipulation works out at 10s. 11d., as compared with 6¾d. for electric driving. Interest, depreciation, and maintenance are not taken into account in this comparison. Allowing 1s. per hour for this amount, as representing a fair amount for a capital outlay of £600, the saving effected by electrical driving would be almost 10s. per lift. E. D. P.

REFERENCES.

926. *Standardisation of Electrical Plant and Testing.* (Amer. Instit. Elect. Engin Trans. 16. pp. 275–288, 1899. See also 1898, Abstract No. 1089.)—Report of Con mittee appointed by the American Institute of Electrical Engineers.

927. *Comparative Advantages of Electricity, Steam, and Compressed Air for Mini Purposes.* **H. S. Childe.** (Instit. Civ. Engin., Proc. 138. pp. 432–435, 1899 ; al *Engineer,* 87. p. 641.)

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

928. *Disposition of Three-Phase Transmission Lines.* **A. J. Bowie, Jr.** (Journal of Electricity, S.F. 8. pp. 105–107, 1899.)—The author states that to eliminate inductive effects it is sufficient to spiral the three wires so that each occupies the middle position for one-third of the length of the line.
W. G. R.

929. *Electrical Plant on Warships.* **J. K. Robison.** (Eng. Mag. 18. pp. 209–222, 1899.)—The author discusses the possible gain due to the use of electricity for all power purposes on warships, with especial reference to their steaming radius. The efficiency of conversion from I.H.P. to B.H.P. is assumed to be 59 per cent., and the steam consumption under the best conditions 26 lbs. per I.H.P., whence there results a saving of 6 per cent. of the total steam used for all purposes. On the other hand, allowing electromotors to have 1·5 times the rated power of the steam engines displaced, for equal torque, and taking a suitable value for the size of the generating plant, it is stated that the electrical machinery would weigh 3½ times as much as steam plant. The resulting loss of coal tonnage being 10½ per cent., the author concludes that electric transmission is inadmissible at present. The development of steam turbines and increased efficiency of conversion offer possible solutions to the problem. [See also Abstracts Nos. 994 (1898), and 759 (1899).]
A. H. A.

930. *Electrical Plant on Warships.* (Mech. Eng. 4. pp. 787–788, 1899.)—In the annual report of the engineer-in-chief of the navy of the United States of America, the use of electrically driven auxiliaries is deprecated, chiefly on the score of weight and space occupied, but also on account of the increased complication and liability to break down. On the battleship *Alabama* the lighting dynamos occupy a space of 10,140 cubic feet, with a capacity of 250 kw. If the plant were increased sufficiently to operate all the auxiliaries, the extra space occupied would be sufficient to accommodate 900 tons of coal, giving 45 per cent. greater coal endurance. (See also 1900, Abstract No. 323.)
A. H. A.

931. *Electrical Equipment of SS. "Oceanic."* (Amer. Electn. 11. pp. 501–504, 1899. Also described in Electrician, 44. pp. 352–354, Jan. 5, 1900.)—This is a description of the electrical equipment of the steamship *Oceanic*, of 30,000 tons. The voltage of the four dynamos is controlled by varying the speed, by altering the tension of a spring in the throttle governor mechanism, or by the stop valve. The negative pole of the dynamos is earthed to the shell of the ship. The equaliser switch forms part of the main dynamo switch, closing before the main switch itself. The load consists of 2,000 glow lamps, about 12 motors for fans, 200 electric heaters, and various cooking and other appliances. The telephonic and signalling apparatus are briefly described.
A. H. A.

932. *Electric Power for Small Users in a 25-mile Radius.* **L. Bell.** (Eng. Mag. 18. pp. 239–248. Nov., 1899.)—The example of the three-phase dis-

tribution at 5,200 volts at St. Victor-sur-Loire is taken, where 1,400 H.P. is distributed to 2,500 looms belonging to small ribbon weavers. The lamp pressure is 110 volts, and pressure for motors is 190 volts. A water-power scheme costing £40,000 is sketched out and the profit on a £10 per H.P. annum rate is estimated. M. O'G.

933. *Cambridge Electricity Supply Works.* (Elect. Engin. 25. pp. 42–49, Jan. 12, 1900.)—The current at 2,000 volts pressure is generated by alternators driven by Parsons' steam turbines; steam at 140 lbs. per square inch being supplied from Lancashire boilers 30 feet long and 8 feet diameter.

A recent increase of plant is a 500 kw. set of dynamo and turbine, the tender for this being considerably below any of those for dynamo and high-speed engine. An equally important consideration is that the space available would not accommodate one engine set, while it is sufficient for two turbine sets. This turbine is of the parallel flow type, and runs at 2,700 revolutions per minute. It is governed electrically, and drives its own air and circulating pumps by means of worm gearing. The consumption of steam per kw.-hour was guaranteed not to exceed 27 lbs. at full load or 30 lbs. at half load, with steam pressure at 140 lbs. per square inch.

Tests at various loads gave the following results:—

Boiler pressure	127	139	145	140
Vacuum	24·75	24·5	26·5	27·5
Water per hour, lbs.	13,400	12,675	7,029	5,180
Output, kilowatts	598	426·4	256·1	124
Water per kilowatt-hour	22·4	24·1	27·5	33·7

H. R. C.

934. *Electric Installation of the Antwerp Railway Station.* **L'Hoest.** (Assoc. Ing. Él. Liège, Bull. 10. pp. 213–222, 1899.)—On account of the want of space at the Antwerp railway station, it was found necessary to build the electric generating station in connection with it at Berchem, at a distance of about 1,500 metres from it. The electric supply is for lighting the passenger station, the large number of shunt lines extending as far as Berchem, the secondary railway station at Berchem, the important adjoining works, and the goods station of Borgherhout. The station also supplies electrical energy for the hydraulic plant of the passenger station, which includes luggage lifts and electric ventilators for the coal conveyer, as well as for the motors of a repairing shop and feed pumps. The mixed system of lighting and traction extends over an area of more than 2¼ kilometres, and includes motors which work intermittently, arc lamp regulators, and, at the furthest point, a load of about 700 incandescent lamps. A complete diagram of connections is given of the system employed, which consists of a continuous current three-wire distribution at 330 volts between the inner and outer wires, boosters and batteries being employed for balancing purposes. L. J. S.

935. *Hydro-Electric Installation of the East Antwerp Railway Statio* **Mélotte.** (Assoc. Ing. Él. Liège, Bull. 10. pp. 222–232, 1899.)—The electr station at Berchem delivers current at 330 volts to East Antwerp to dri 10 kw. shunt motors coupled to hydraulic pumps, which force water at atmospheres into accumulators for the purpose of working hydraulic lif Eleven of these lifts are for raising loads of 1,400 kilogrammes and f others for raising 1,000 kilogrammes.

[redacted]

Hydraulic lifts were used in preference to electric lifts owing to the fact that apart from the above lifts it was necessary to employ elevators for raising railway trucks weighing 18 tons at a speed of 50 centimetres per second, which would have necessitated the use of electric motors of too large a size.

L. J. S.

936. *New Plant at Niagara.* (Amer. Electn. 11. pp. 547–551, 1899.)—A description of recent additions in the power house of the Niagara Falls Hydraulic Power and Manufacturing Company. A direct current machine, built by the General Electric Company, having an output of 5,000 amperes at 175 volts, has been installed. This machine has a commutator at each end of the armature, the two sets of brushes are coupled in parallel, the division of the load between the commutators being accomplished by varying the lead of one or other set of brushes. The division of the load is shown by a Weston ammeter coupled across the similar brushes of the two commutators.

This machine is coupled at one end of a shaft driven by a pair of wheels of the Jonval type. The wheels are 60 inches in diameter and are rated at 3,000 H.P. for the two, when running at 250 revolutions per minute under a head of 210 feet. Coupled to the other end of the shaft is a Walker alternator for incandescent lighting. It is of the revolving field type, is single-phase, has an output of 900 kw. and a frequency of 125. A shunt-wound generator, by the General Electric Company, 200 kw. and 135 volts, has been installed.

Two new and complete sets of turbines and generators for the Pittsburg Reduction Company have just been completed. The generators, two of which are coupled to each set of turbines, have each an output of 2,500 amperes at 300 volts.

These new sets of plant are all described fully, illustrations are given, and also a short account of further proposed extensions. The total capacity of the plant at present is 9,560 kw. [See Abstracts Nos. 1404 (1898) and 924 1899.]

E. D. P.

937. *Alternate-Current Power Transmission at Sihl, Rathausen, and Olten-Aarburg.* C. du Riche Preller. (Engineering, 69. pp. 37–40, Jan. 12, 1900.)—The three installations which the author describes are those of the Sihl Works (Canton Zurich), the Rathausen Works (Canton Lucerne), and the Olten-Aarburg Works (Canton Aargen), all of which utilise their full hydraulic power, and therefore constitute interesting examples of self-contained central stations transmitting and distributing energy over large areas and for the most varied purposes.

(1) The *Sihl Power Transmission* is situated on the river Sihl about 16 kilometres from Zurich, and utilises the power of that river, the available average volume being about 3 cubic metres per second, at a fall of about 70 metres, equal to 2,000 effective H.P. on the turbine shafts. The power station contains five 400 H.P. high pressure turbines, coupled to superposed two-phase 5,000-volt alternators. The average power required for lighting amounts to 784 H.P. on the turbine, or 575 effective H.P. at the lamps, so that of the total number of lamps installed, about three-fourths burn simultaneously as a maximum, the total efficiency being 74 per cent. The average power required for the motors is 786 H.P. on the turbines, equal to 582 effective H.P. at the motors, the total efficiency being the same as that of the lighting system, viz., 74 per cent. The aggregate installed power of the motors is utilised by consumers to the extent of about 62 per cent., the surplus power being in many cases

equal to 40 H.P. of installed power (lamps and motors) per kilometre, or 64 H.P. per mile. Apart from the fifth turbo-alternator set, which is kept as a reserve, there is a 300 H.P. steam-alternator as a further reserve. The total cost of construction, transmission, and distribution, works out to £42 8s. per H.P., and the net earnings amount to 5 per cent. on the capital.

(2) *Rathausen Power Transmission.*—The power station is situated on the river Reuss, about 4 kilometres from Lucerne. The average water power utilised is 3–4 cubic metres per second at a fall of 4-5 metres, equal to 1,500 effective H.P. on the turbine shafts. The power station comprises five turbines of 300 H.P. each and five superposed 3,500-volt two-phase alternators. A reserve 300 H.P. steam alternator has also been installed. The aggregate installed power (lamps and motors) is close upon 1,000 H.P., the average power supplied at the time of maximum consumption being 1,300 H.P., or at 74 per cent. of the system, 1,800 H.P. on the turbine shafts. The power actually paid for by the consumers amounts to 1,400 H.P. The mileage of primary transmission is equal to 70 H.P. of installed lamps and motors per kilometre, or 112 H.P. per mile. The total cost of construction, transmission, and distribution works out to £47 4s. per H.P. The net revenue amounts to 5 per cent.

(3) *Olten-Aarburg Power Transmission.*—The power station is situated on the river Aare, about 4 kilometres south of the well-known Olten Railway Junction. The average water power utilised is 100 cubic metres per second at a fall of 3 metres, equal to 3,000 effective H.P. on the turbine shafts. The power station contains ten low-pressure turbines of 300 H.P. coupled to 5,000-volt alternators, while two other 5,000-volt alternators are actuated by two turbines each. The aggregate power of the installed lamps and motors, therefore, amounts to 1,800 H.P., or, at 74 per cent. total efficiency, to 2,400 H.P. on the turbine shafts, so that of the total available power of 3,000 H.P., two sets of turbo-alternators of 300 H.P. each or one set of 600 H.P. are used as reserve. The mileage of primary transmission is equal to 22 H.P. installed lamps and motors per kilometre, or 35 H.P. per mile. The total cost of construction, transmission, and distribution amounts to £53 8s. per H.P. The net profit amounts to 4 per cent. on the capital. Particulars are given of the charges for energy and light, cost of construction, &c.

L. J. S.

938. *Power Station, Merrill, Wis.* **F. E. Woodford.** (Amer. Electn. 11. pp. 551–553, 1899.) — Description of the generating station of the Merrill Railway and Lighting Company, which presents a unique arrangement of combined hydraulic and steam power plant. There are several turbines and generators coupled on one shaft, the machines being used for both lighting and traction purposes. The power house is built on the riverside, the flumes, which contain the wheels, being a part of the dam. Upon the rock-bed of the river are built the flume walls, which also serve as foundations for the works building. The wheels are 42 inch, of the upright type, and run at 102 r.p.m., under a head of 12 feet. Directly above t[illegible] wheels an iron harness extends the full length of the building, and ser[illegible] as a foundation for the electrical generators and for the yokes of the m[illegible] shaft bearings. The four wheels are geared to this horizontal shaft, u[illegible] which the armatures of the generators are mounted, and which exte[illegible] the full length of the building. One end of the shaft passes through outer wall, at which end power is applied to it by the steam eng[illegible] Clutches are arranged in the shaft so that loads on generators and wh[illegible]

can be changed. The generators are of General Electric manufacture, two of 250 volts, which run in series, and one of 500 volts. A battery of accumulators is installed, and from this the lighting circuits are fed by five wires. Arc lighting machines are driven by belts from the main shaft. The steam plant is in a separate building, and is at present used only when the river is very low. It develops 250 H.P. at 90 r.p.m., and is coupled by belt to the shaft extension. The operation of the plant is exceedingly simple ; very little adjustment is necessary with the battery across the mains, one attendant only being required at any time. E. D. P.

939. *Coventry Electric Tramways.* (Elect. Rev. 46. pp. 187–190, Feb. 2, 1900.)—The chief point of interest in the equipment of these lines is a special "constant pressure" trolley standard, designed for going under low bridges without increasing the pressure on the trolley wire. The springs are all concealed in the body of the standard, and a cam makes their leverage depend on the slope of the trolley pole. On the bracket-arms, the insulators are supported by bowstrings fixed in harps. E. H. C.-H.

940. *Statistics of German Tramways.* **W. Mattersdorff.** (Elektrotechn. Ztschr. 20. pp. 885–886, 1899.)—Tabulated data and curves are given of the receipts and car-kilometres run, &c., of the following tramways :—

(1) Berlin tramways (Grosse Berliner Strassenbahn). (2) Vienna tramways. (3) Two tramway Companies, operating in Dresden. (4) Hamburg tramways.

The receipts, &c., for the last twenty years of the first-named are given in a table, part of which is reproduced.

Year.	Receipts in marks.	Car kilometres.	Pfennige per car kilometre.
1879	4,530,372	6,242,634	72·6
1884	8,710,985	13,465,335	64·8
1889	13,218,435	21,939,779	60·4
1894	14,700,755	26,809,760	55·0
1898	18,612,710	37,772,595	49·4

E. K. S.

941. *New York Electric Conduit System.* (Street Rly. Journ. 16. pp. 15–23, Jan., 1900.)—The conversion of 29 miles of the Third Avenue Railway Co.'s main lines from cable to underground electric conduit is now completed : another 29 miles is in progress. Radical innovations in track and car construction have been introduced, and the main power station, containing 96,000 H.P., is the largest in the world.

The notable new features in the track are the use of cast-welded joints in conduit construction, the combination of steel and cast-iron yokes, the employment of a continuous creosoted stringer under the rail at all points except at special work, and the use of a spring liner between the base of the rail and its seat on the yoke. On the Third Avenue line the cable was retained till the last moment, the change of each section to the electric system being effected in twenty-four hours.

The new form of car is a 32 feet convertible car, opened or closed, of which dimensioned plans are given. The dashboards carry the controller, the sand-box handle, the air-brake handle, and the hand-brake handle. A double-pressure gauge shows the pressure in the reservoir and in the jam cylinder. A special device has been added to facilitate finding the "lap"

position of the air-brake handle. The plough differs in details from the design used by the Metropolitan Street Railway Co., but will run over that Company's tracks.

A temporary 6,000 H.P. station was erected and running within three months from the signing of the contract. (See also 1899, Abstract No. 944.)

E. H. C.-H.

942. *Kingsland's Contact System.* (Elect. Engin. 24. pp. 660–661, 1899.)—The contact plates on the track surface are connected with the feeders through two pairs of commutators coupled by sectional mains. The commutators are carried on the spindle of a four-point star, fixed below a slot formed by a guard-rail outside the track-rail. A striker on the car revolves each pair of commutators through a quarter turn when it passes the star wheel. The arrangement of contacts is such that when one of the sectional mains between two pairs of commutators is connected to the feeder at one end, it is insulated at the other, while its fellow is disconnected from the feeder. The system is to be tried on an experimental line at Wolverhampton. E. H. C.-H.

943. *Cure of Electrolysis by Independent Earth Returns.* **C. A. Newbaker.** (Amer. Electn. 12. pp. 72–74, Feb., 1900.)—The streets of large cities are particularly favourable to electrolytic action on lines of metal laid under them, because the ground contains a large accumulation of impurities which form acids and alkalies for electrolytes. Lead has a high electrochemical equivalent: that is, a large amount of it is dissolved per ampere hour of current flowing from it, and therefore unfavourable earth conditions cause its rapid decomposition.

A peculiarity of electrolytic action is that no metal is dissolved where the current flows into a pipe, but all metals are liable to be attacked by current leaving the pipe and flowing into the material surrounding it. On account of this and the fact that the positive pole of the dynamos is to line, the tendency is to localise all the trouble in the district near the power house.

The independent return method of curing electrolysis consists in running metallic connections from all underground piping, cable sheathing, &c., to the return circuit of the traction system at all *points where the current tends to leave the piping and return to the traction circuit.* Current leaving the pipes *viâ* a metal path does no harm, and as the current entering the pipes is also harmless, this method, where thoroughly carried out, is a very satisfactory one. The return should be of stranded copper (tinned) connected to lead cable sheath by means of a looped joint and to the tram rails either by a soldered joint to a cross bond or by a separate bond to the track itself.

Thorough tests should be made for electrolysis at intervals of six months or oftener if changes in the conditions of distributing power are known to have occurred. A telephone company, for example, may at one time make tests and find that its system is, on the whole, safe, and a little later find that a highly dangerous condition exists. This sudden change may be due to a lowering of the potential of the ground below that of the track by auxiliary returns run by some other corporation operating over the same territory, such as a water or a gas company. This is a condition to be watched for at a[illegible] times, as the protection of one set of pipes is likely to cause danger to anothe[illegible]

The author describes a method of making systematic tests and how to pl[illegible] curves showing the distribution of potential over a piping system and adjace[illegible] ground before and after using an independent return, &c. The edges [illegible] the hole burned into the cable sheath by a heavy current are square as thou[illegible]

the hole were punched out, whereas the edges of a hole made by electrolysis are thin like those of a dull knife-blade. Electrolysis always causes grainy, rough surfaces, and its apparently freakish tendency to attack in spots and form ridges is probably due to a lack of homogeneity in the metal.

The current in a return may be read by a milli-voltmeter giving the voltage between two points a few feet apart, the current being calculated on the basis of 10 ohms per foot per circular mil. This obviates thé necessity of cutting the return to insert an ammeter. E. K. S.

944. *Trolley-Wire Guards.* **Moens.** (Assoc. Ing. Él. Liège, Bull. 10. pp. 259–264, 1899.)—Trolley-wires are divided into two classes: those which merely prevent contact with the trolley-wire, such as insulated guard-wires, insulated trolley-wire coverings, &c.; and those which earth the trolley-wire when contact is made. In all cases telegraph and telephone circuits should be protected by fuses which blow at 0·1 to 0·2 amperes. Ulbricht has devised a system to avoid the dangers attendant on the guard-wire coming in contact with the trolley-wire. The former is earthed through the coil of an electro-magnet actuating a switch which earths the trolley-wire direct and thus opens the station cut-outs. L. B.

945. *Trolley-Wire Guards.* **Pedriali** and **d'Hoop.** (Assoc. Ing. Él. Liège, Bull. 10. pp. 302–309, Jan., 1900.)—Trolley-wires may be protected from falling telegraph- or telephone-wires either by guard-wires or by an insulating covering on the upper surface of the trolley-wire itself. Guard-wires are comparatively complicated, unsightly, costly, and dangerous, and in many towns, particularly in Germany, are being replaced by a strip of insulating material clipping the upper part of the trolley-wire. L. B.

946. *Trucks for Electric Tramways.* **G. Dary.** (Électricien, 18. pp. 363-366, 1899.)—A description of three models of the Baltimore trucks, the first being the maximum traction bogie type with small and large wheels. The second is an extra long car truck, and the third a bogie truck for heavy cars. The frames are of very neat design of flanged pressed steel with cast steel axle-boxes. Particulars are given of the methods of spring suspension. E. K. S.

947. *Recent Experience in Rail-bonding.* **H. P. Brown.** (Eng. News, 42. p. 239, 1899. Abstract of a paper read at the Toronto Meeting of the American Society of Municipal Improvements.)—Two years ago copper wire riveted into the rail was abandoned in favour of short flexible "leaf" bonds, generally placed under the fishplates. The ends of the bonds were brazed or cast into lugs, which were expanded into the rail holes either by screw pressure or by taper plugs. Tests have shown that screw-compressed terminals turn when the weight at the end of an 18-inch lever arm reaches 143 lbs.; with taper steel plugs 65 lbs. turns the bond. The latter are, however, found best, as the poor mechanical joint prevents the severe mechanical strain on the copper wires which is found to cause crystallisation and breakage of the screw-compressed bonds. A promising new bond consists of a solid copper bar, $\frac{1}{8}'' \times 3'' \times 2''$, having a projecting contact cup pressed on each end. The bond is placed under the fishplate, and is held against the rails by a strong steel spring in each cup.

In Indianapolis, where the power-house output is 2,800 amperes, the water

pipes are carrying 1,400 amperes with a maximum positive pressure of 8·2 volts. These measurements were made since the installation of cast-weld joints; previously the maximum positive pressure was only 6·8 volts, and the "dangerous" area for pipes was only half what it now is. The author advocates the introduction of iron-banded wooden pipes at intervals in the water mains. E. H. C.-H.

948. *German Electric Automobiles.* (Elect. World and Engineer, 34. pp. 692–693, 1899.)—A primary battery motor-car is described. The plates are zinc and lead peroxide, the latter of which is charged and loaded with acid. The battery for a 40-mile run only weighs 42 lbs. Another motor-car has a small battery of accumulators, an electric motor, and a petrol engine which receives electrical assistance on heavy gradients and on starting, but normally charges the cells. The weight is less than an accumulator-driven car, and the cost £240. An electric accumulator omnibus running in Berlin is described. M. O'G.

949. *Electric Automobiles.* **E. A. Sperry.** (Amer. Inst. Elect. Engin., Trans. 16. pp. 533–549. Discussion, pp. 549–551, 1899.)—The author found that the amount of side-thrust transmitted to either guide-wheel of his motor-car is proportional to the distance between the steering axis and the plane of the wheel at the height of the obstruction. He therefore designed a gear with its steering axis intersecting the plane of the wheel some distance above the ground, and found that obstructions which caused a lateral pull of 10 lbs. on an ordinary steering handle gave no pull on the handle of his gear. Another result of the obliquity of the steering axis is that the vehicle tends to run straight forward if not guided. For automobiles, the best tramway practice can be followed in the main, but the motor may have an increased ratio of copper to iron. A compound adjustable gear is an advantage for emergencies and saves the battery. Double-reduction gear permits the use of a powerful brake on the intermediate shaft and of a higher speed bi-polar motor, which is slightly more efficient than a multi-polar. Efficiency is all-important in an automobile because the source of power is not at hand. The author recommends the use of a single handle, whose direction should indicate the direction of the vehicle's motion, speed being regulated by raising and lowering the handle, which operation applies the brakes automatically. For charging batteries, the differential wattmeter system is advised. E. H. C.-H.

950. *Working Expenses of Horse and Electric Delivery Vans.* **G. F. Sever** and **R. A. Fliess.** (Amer. Inst. Elect. Engin., Trans. 16. pp. 509–531, 1899.)—This paper sets forth the results of an investigation on horse and electric vans belonging to large stores in New York. Their average load throughout the day is 500 lbs., and the average "draw-bar pull" at 7 miles per hour is 60 lbs. per ton on cobblestones; on asphalte, 40 lbs. The van tested weighed 1,800 lbs., and its horse 1,100 lbs. A day's "log" of a van is given, from which it appears that the average daily work of a horse in such service is 16·5 miles at 50 lbs. per ton at 7 miles per hour, while the cost of horse, van, and attendance is 364 cents per day, or 17·4 cents per ton-mile. If a second horse is kept, these figures respectively become 428 cents per day and 10·2 cents per ton-mile.

A similar "log" for an electric delivery van is given, and shows an average consumption of 92 watt-hours per ton-mile. The authors are

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opinion that 120 watt-hours per ton-mile is a conservative estimate for a well-designed delivery van under service conditions. At 5 cents per kw. hour, the cost per lb. (of parcels only) is 0.019 cents, as against 0·020 cents for horse service, making all assumptions in favour of the horse. Depreciation is not taken into account in any of the figures. E. H. C.-H.

951. *Electric Automobile.* (Automotor Journal, 4. pp. 163–164, Jan., 1900. Adapted from an article by A. Delaselle in La Locomotion Automobile.)—Two four-pole motors are used with armatures vertical, and the motor frames resting directly on the axles of the fore-wheels. The steering is ingeniously effected by pivoting the short steering axles on the centre lines of the driving pinions. M. O'G.

952. *Traction Accumulator Trials.* **A. Bainville.** (Électricien, 18. pp. 161–163, and 329–332, 1899; see also Abstract No. 408, 1900.)—It was not foreseen in the rules that certain batteries would become reversed during the variable discharges before being brought up for the constant rate trials in which they are eliminated. Hence in comparing cells from the published results their merits must be measured by the watt-hours given off, and not by the number of variable discharges they have been submitted to. The shaking test was frequently omitted, owing to breakdowns of the apparatus. M. O'G.

953. *Traction Accumulator Trials.* **A. Bainville.** (Électricien, 18. pp. 398–400, 1899.)—The French Automobile Club trials are summarised as follows:—

Number.	Names of Competitors.	Total Weight.	Total Output. Watt-hours.
		Kg.	
1 F	Société anonyme pour le travail électrique des métaux. Paris	104	764
2 L	Compagnie générale électrique. Nancy. "Pollak" plates	119·5	795
3 K	Société Tudor. Paris, Bruxelles, and London	125·7	1,358
8 Q	Lagarde. Paris	89	363
9 E	Wuste et Rupprecht. Vienna (Austria)	70·25	145
11 N	Société de l'accumulateur Fulmen. Clichy	76·5	1,022
13 I	,, ,, ,,	83	318
17 P	Société des soudières électrolytiques. Gavet-Clavaux (Isère)	77·5	446
18 J	Franz-Heimel. Vienna (Austria)	59·5	360
19 M	W. Pope and Son. Slough (England). "Sherrin" plates	86·3	375

M. O'G.

954. *Traction Accumulator Trials.* **É. Hospitalier.** (Électricien, 19. pp. 20–26, Jan. 13, 1900.)—This complete summary of particulars of the eight best cells shows the weights of plates, liquid, cases, total energy taken in and put out, &c., by the cells before they failed in the trials by the French Automobile Club. Thus the *total energy given out in watt-hours*, divided by the total weights in kgs., is as follows: Metaux, 9·7; Pollak, 8·8; Tudor, 8·9; Pescetto, 8·7; Blot Fulmen, 9·8; Fulmen, 15; Phœnix, 12·5; Pope-Sherrin, 11·5.

The data enable the cells to be very well compared. M. O'G.

955. *Series Arc Lighting from Constant Current Transformers.* **W. L. Robb.** (Amer. Inst. Elect. Engin., Trans. 16. pp. 557–564. Discussion, pp. 565–578, Nov., 1899.)—The author refers to the various methods which have been adopted for operating series arc lamps from alternating current systems. In several well-known stations in the United States continuous current series arc dynamos are driven by synchronous or induction alternating current motors. Before deciding on the system described in this paper and in use at Hartford, consideration was given to the above system and to the use of rectifiers.

The development of the enclosed arc lamp quickly led to the evolution of a satisfactory alternating arc lamp of the constant potential variety, and experiments were carried out for operating these lamps from the constant current transformer, which formed one of the essential parts of the rectifier.

These experiments proved quite satisfactory, which led to the replacing of all the continuous current series arc dynamos by constant current transformers, with a view to obtaining a greater economy of operation.

Each transformer is immersed in transil oil and is contained in a cast-iron tank. The core of the transformer is placed vertically and rises the whole height of the tank. The core is surrounded by the primary and secondary coils, and the magnetic circuit is closed by return paths outside the coils. There are two primary and two secondary coils, and one of the primaries is fixed at the bottom and the other at the top of the central core. The two secondaries are free to move up and down between the primary coils, and are so connected together that when one falls the other rises. The coils are balanced by a system of chains, levers, and counterweights. When the transformer is in operation the currents induced in the secondary react on those in the primary and tend to force the coils apart. This force is balanced for the desired normal current by the adjustable weight outside the case.

The principle of regulation was first suggested by Elihu Thomson, and its application to the operation of constant current transformers is broadly patented by him.

By bringing out the proper connections from the secondaries the total number of lights may be operated as a single circuit, or operated in any desired number of multi-circuits in a manner similar to the well-known method employed on the Brush series dynamos of large capacity.

Owing to the high voltage of the enclosed arc lamp the 100-light transformers usually operate two circuits connected upon the multi-circuit principle.

The transformer can be adjusted so as to give practically a constant current between one-third load and full load. Curves are given showing the range of regulation that can be obtained by means of the adjustment provided.

Tests showed that when the transformers were adjusted to give a constant current through any desired range of load, that the lamps would draw different lengths on the arcs depending on the number of lamps on the circuit. The voltage across the terminals of the individual lamps was approximately 10 volts higher at one-fourth load than at full load, although the current was the same in both cases. It has been found, however, that by varying the adjustment of the transformer, it is possible to adjust it so that the voltage across the terminals of the individual lamps remains practically constant at various loads. If so adjusted, however, the current from the transformer is no longer constant but increases as the load increases.

The averages of tests made on two 100-light transformers were as follows :—

Load.	Efficiency.	Power Factor.
¼	88·1	24 per cent.
½	92·8	44 „
¾	94·9	62 „
Full	96·1	78 „

The rise in temperature of the oil of the transformer measured at the top of the iron core, where it was highest, was 39° C. after a twenty-four hours' run.

The low power factor at small loads and difficulty in maintaining the lamps at constant voltage when the current is constant at various loads, combine to make the constant current transformer undesirable except when the conditions are such that it is possible to operate the transformer under a large part of its rated full load. It has been found in practice that the transformers can be maintained and operated successfully with very little attention.

The primaries of the transformers are connected across the 2,400-volt alternating current feeders. Although the voltage at the terminals of the primary of the transformer is subject to a variation of 5 per cent. during street-lighting hours, the current supplied to the series lighting circuits is practically constant.

The lamps operated from the constant current transformers are of the carbon feed enclosed type. The frequency is 60. The lamps used in Hartford consume at the transformer 400 watts per lamp, and replaced nominal 1,200 c.p. open-air direct current arcs. The streets are undoubtedly better lighted with series enclosed arc lamps than they were formerly with the open-air arcs. The power required under the local Hartford conditions for operating street lights has been reduced in the ratio of 550 to 400 watts, or a little over 27 per cent.

The author concludes with the statement that the system of street lighting which will be found best for any given city depends largely upon the local conditions; but there are undoubtedly many cases where an investigation will show that the adoption of the constant current transformer and the series alternating current arc lamp offers the greatest advantages.

The paper is followed by a lengthy discussion. L. J. S.

956. *Lacko's Arc Lamp.* (Elekt. Runds. 17. pp. 54–55, Dec. 15, 1899.)—This lamp is due to D. Lacko of Paris, and comprises a worm-wheel which gears at opposite sides with racks bearing the carbon-holders at their lower ends. On the same axis as the worm-wheel there is also mounted an oscillating frame on which are pivoted two auxiliary frames. The first of these frames carries the worm-shaft and is provided with an armature acted upon by a solenoid in the main circuit, a spring being provided for holding the frame in such a position that the worm is out of engagement with the worm-wheel when there is no current flowing through the lamp. The second auxiliary frame bears a feed-pawl adapted to engage with a ratchet-wheel on the worm-shaft, a spring being arranged to act on the frame in opposition to the pull of the shunt electromagnet on an armature attached to the frame. This second frame is also provided with an adjustable set-screw which, when the armature on the frame has been drawn down and the worm has been rotated by the ratchet-wheel and pawl, breaks the circuit of the shunt electromagnet and allows the spring to return the frame to its normal position ready to again rotate the worm through a similar angle. In starting the lamp, the series electromagnet attracts the armature on the first

auxiliary frame so as to bring the worm into engagement with the worm-wheel, and then cause the main frame to oscillate so as to strike the arc. When the shunt electromagnet becomes stronger, by reason of the rise of potential during the burning away of the carbons, the second auxiliary frame is drawn down against the tension of its spring and the worm rotated through the feed-pawl; when this frame has reached the end of its travel it returns to its normal position as above mentioned, and so on. The original paper is illustrated. C. K. F.

957. *High-voltage Lamps.* (Electrician, 44. pp. 118–119, Nov. 17, and 153–155, Nov. 24, 1899.)—In the first part of this paper are given illustrations of lamps from the various makers showing the shape of filament and type of lamp. In the second part are shown curves of the c.p. and watts per c.p. The first curve gives a typical efficiency curve, taken by a leading English lamp manufacturer on a circuit occasionally exceeding the normal voltage by 4 per cent.; the watts per c.p. start at 3·7 and fall to 3·6 in the first 100 hours, then increase to 4·3 in a 1,000 hours. Various other life-curves are also given.

Robertson recommends an efficiency of 4 watts per candle for 16 c.p. lamps of high voltage, and that this figure should be allowed to increase somewhat, say to 4·5 watts per candle, for candle-powers of 8 and less. Stearn states that about 80 per cent. of the lamps he manufactures are for voltages of 200 and over. The Sunbeam Company choose as their standard efficiency 3·75 watts per c.p. for 16, 25, and 32 c.p. lamps, but for 8 c.p. lamps do not recommend a higher efficiency than 4 watts per c.p. They have found in their own testing-rooms that such lamps have practically as good a life-curve as an ordinary low-voltage lamp, and that the efficiency is certainly well maintained in a 500 or 600 hours' run with a drop of not more than 3·5 candles, at which point, of course, consumers should renew their lamps. Smaller lamps than 8 c.p. have not such a good efficiency. To be satisfactory a 5 c.p. lamp requires some 4·5 to 4·75 watts per c.p. The Berrenberg Company promise great things as regards efficiency, promising 2 and 2·5 watts per c.p. for 16 c.p. and 8 c.p. lamps over a fairly long life. Goossens, Pope & Co. make their standard lamps of the following efficiencies: 5 c.p., 4·5 watts per c.p.; 8 c.p., 4 watts per c.p.; 16, 25, and 32 c.p., 3·5 watts per c.p.; 50 and 100 c.p., 3·3 watts per c.p.

The Electric "Tested Lamp" Co. give curves of a good English 200 volt 16 c.p. lamp, and also of a bad one of the same voltage and c.p. In the first the c.p. starts at 15·6, rises to 17·4 in 96 hours, and then falls to 16 in 576 hours, after which it falls very rapidly. The corresponding watts per c.p. are 3·9, 3·7, and 4. In the case of the bad lamp the corresponding figures are: c.p., 14·8, 19·8, and 11·6; watts per c.p., 4·2, 3·6, and 5·8. They also give a curve of a bad Austrian lamp, which is still worse. Mention is made of a device of A. G. Seaman, brought out by the "Tested Lamp" Co., for an automatically adjusted rheostat connected to a voltmeter relay, which is intended to be placed between the supply mains and the consumer's distribution board to prevent the over-running of lamps.

Attention is drawn to the difference between the English standard candle and the Hefner amyl-acetate standard, as some English makers employ the latter in rating their lamps. A 16 c.p. lamp, if named according to the Hefner unit, would give only about 14 candle English standard power, and a lamp requiring 3·5 watts per Hefner standard required nearly 4 watts per English standard. E. C. R.

958. *Scientific Principles of Arc Lighting.* **F. W. Carter.** (Elect. Rev. 45. pp. 994–995, Dec. 22, and 1034–1037, Dec. 29, 1899.)—The author obtains expressions for the total illumination, the horizontal illumination, and the vertical illumination, at any point due to an elevated source of light considered as a geometrical point. These expressions are respectively $I \cdot \cos^2\delta/(h-h^1)^2$, $I \cos^3\delta/(h-h^1)^2$, and $I \cos^2\delta \sin \delta/(h-h^1)^2$, where I is the candle-power of the source in the direction of the point considered, δ is the inclination of this direction to the vertical, h is the height of the source above the ground, and h^1 is the height of the point considered. From these expressions the author gives a geometrical construction for finding polar and cartesian curves for these three illuminations when the photometric curve of the source is given. The theory is extended to the combined effect of two or more independent sources of light. W. G. R.

959. *Electric Train Lighting.* **H. Massenbach.** (Elektrotechn. Ztschr. 21. pp. 50–52, Jan. 11, 1900. Paper read before the Elektrotechn. Gesellschaft, Frankfurt-a-M., Dec. 6, 1899.)—The general advantages of electric train lighting are described and details are given of the system developed by Vicarino. This closely resembles that used by the Electric Axle Light and Power Co. of New York, under Moskowitz's patents (see 1900, Abstract No. 779). A dynamo is placed under each car driven by leather-faced friction wheels from the axle. The voltage is kept constant by a reversed compound winding. The battery and automatic switching and regulating devices are described. Photometric comparisons between gas and electric lighting are given and detailed estimates of cost under each system. This amounts to 0·28d. per 10 c.p. lamp hour for gas against 0·21d. per 12 c.p. lamp hour for electric lighting. L. B.

960. *Electric Train Lighting.* (Elect. World and Engineer, 34. pp. 867–869, Dec. 2, 1899.)—An illustrated description of the method employed by the Electric Axle Light and Power Co. of New York. A 40-volt dynamo is geared by friction wheels to an axle of each car, the pinion having a fibre face. This charges a battery carried under the car body. The automatic switches for connecting the dynamo to the circuit when the speed is high enough, disconnecting when the speed falls, and reversing when the car is required to run in the opposite direction, are mentioned but not described. L. B.

REFERENCES.

961. *Railway Drawbridge in Boston.* (Street Rly. Journ. 16. pp. 37–38, Jan., 1900.)

962. *Subway at Kingston, U.S.A.* (Street Rly. Journ. 15. pp. 861–864, Dec., 1899.) —Description of a subway at Kingston, N.Y., for trolley cars, beneath the West Shore Railroad tracks.

963. *Electricity in Powder Works.* **W. H. Allen.** (Elect. World and Engineer, 34. pp. 733–735, Nov. 11, 1899.)—An illustrated article dealing with the electrical equipment, for both lighting and power, of the Californian Powder Works. E. D. P.

964. *Third-rail Conductors for Electric Railways.* **L. Daft.** (Cassier, 17. pp. 235–239, Jan., 1900.)—The paper contains drawings showing the design and con-

965. *Electrical Power for Drainage, New Orleans.* **L. C. Reed.** (Elect. World and Engineer, 34. pp. 771–775, Nov. 18, 1899.)—The various and widely scattered pumping stations of this scheme are operated by three-phase currents transmitted from a main generating station. A general description of the system is given.
E. D. P.

966. *Bromley and Chislehurst Electric Lighting.* (Electrician, 44, pp. 462–467, Jan. 26, 1900.)—The high-pressure direct-current system is used. Power is transmitted at 2,000 volts pressure from the generating station at Bromley to a substation of direct-current transformers and batteries at Chislehurst, a distance of 2¾ miles. A full description of the system is given, with illustrations. E. D. P.

967. *Bolton Electricity Works.* (Elect. Rev. 46. pp. 101–105, Jan. 19, 1900.)—A fully-illustrated description of these large works, in which power is generated for both traction and lighting purposes ; also some particulars of the outdoor construction in connection with the trolley tramway scheme. E. D. P.

968. *Electricity Works at Bonn.* **P. Bauer.** (Elektrotechn. Ztschr. 20. pp. 850–856, 1899.)—A full description of the electric light station equipped by Siemens & Halske on the continuous current three-wire system with accumulators, and 440 volts across the outers. The dynamos are of the Gramme multipolar type, with the armature revolving outside the poles. E. K. S.

969. *High Tension Transmission in the United States.* **C. E. Guye.** (Écl. Électr. 21. pp. 241–249, 452–456, and 487–491, 1899.)—Description of some transformers (pp. 241–249). Testing the Telluride line (pp. 452–456). High tension experiments at East Pittsburg (pp. 487–491).

970. *Transmission of Energy by Alternating Currents.* **M. Leblanc.** (Soc. Int. Élect., Bull. 15. pp. 416–460, 1898, 16. pp. 54–102, 112–159, 316–344, and 349–385, 1899.)—Series of papers similar to those referred to in Abstract No. 749 (1900).

971. *Electrical Distribution.* **C. F. Guilbert.** ((Écl. Électr. 19. pp. 281–289, 401–410, 1899, 22. pp. 13–21, Jan. 6, 1900.)—Appliances described of Thomson-Houston, Steinmetz, Schuckert & Co., for Alternate Current Distribution (pp. 281–289). Description of System of Direct Current Distribution, patent by Bliss (pp. 401–410). Also various patent devices in connection with the distribution of energy ; among others, methods due to C. F. Scott, to the Westinghouse Company, the Electric Construction Company, Thomson-Houston Company, and to Messrs. Verity & Steele are dealt with (pp. 13–21).

972. *Aluminium Feeders on the North-Western Elevated Railroad, Chicago.* (Amer. Electn. 12. pp. 20–23, Jan., 1900.)—An article describing and illustrating the methods adopted in laying some large bare aluminium feeders.

973. *Third Avenue Railroad Power Station, New York.* (Street Rly. Journ. 16. pp. 1–12, Jan., 1900.)—A full description of the large new works which the Third Avenue Railroad Company of New York are about to erect, dealing more particularly with the works structure and the steam plant, about 100,000 H.P., which it is proposed to instal. (See 1899, Abstract No. 944.) E. D. P.

974. *Distribution of the Energy of Coal in the Working of Electric Traction.* **A. B. Herrick.** (Street Rly. Journ. 16. pp. 12–14, Jan., 1900.)—The author splits up the working of electric traction into many parts, and deals with the losses taking place and the possible economies to be obtained in each. A coloured chart is included, which shows graphically the magnitude of the various losses in street railway operation ; the losses are divided up very completely, eighty-nine sections being represented on the chart. E. D. P.

[redacted]

TELEGRAPHY AND TELEPHONY.

975. *Wireless Telegraph Patents.* (Electrician, 43. pp. 847–850, 1899.)—Marconi has applied for eight patents since No. 12,039 of 1896. (See Electrician, Sept. 17, 1897.) No. 29,306 of 1897 provides for an automatic shutter closing the box which protects the coherer when the transmitter is used. No. 12,325, June 1, 1898, deals with the iron enclosure of the receiver. No. 12,326 of June 1, 1898, describes how the tall-wire is connected to earth not through the coherer but through the primary of a coil, of which the secondary is wound in such a way that the number of turns in each layer is diminished as the distance from the primary increases. It is stated that "the effect of the oscillations on the imperfect contact increases greatly with their E.M.F. and not with their quantity." Full dimensions are given as a guide to constructing the apparatus. The special coils are described in No. 6,982, April 1, 1899. O. Lodge's patent, No. 11,575, of May 10, 1897, describes the use of a coil with its primary between the receiving wire and earth. M. O'G.

976. *Wireless Telegraph Repeater.* (Elect. Rev. 45. pp. 749–750, 1899.)—Foresio's instrument can be used as transmitter, receiver or repeater by a three-way key. A coherer is made to actuate the induction coil. It is proposed to use a metal partition between the receiving tall-wire and the retransmitting wire, and so keep the effects distinct. Two such apparatuses are required to retransmit in both directions. M. O'G.

977. *Wireless Telegraphy Without a Coherer.* (Elect. Rev. 45. pp. 1026–1027, 1899.)—W. B. Starkey uses a pivoted needle of silver strip, having one end in proximity to the receiving vertical wire; this needle moves into contact with the vertical wire with sufficient force to close a local bell circuit. With aërial conductors 8 feet high the talking distance was 86 feet. M. O'G.

978. *Dardeau's Telephonic System.* **E. Piérard.** (Électricien, 18. pp. 409–412, and 426–429, 1899.)—This is a system by which any two or larger number of stations can inter-communicate upon one common circuit. There are two keys and an Ader relay in the line circuit in each office. When key A, say, is pressed at any office the tongues of the relays in all the offices move to the left, and by means of an electromagnet in a local circuit cause a needle to indicate upon a dial in each office that a call is being made. Each time now that key B is pressed the needle moves one step further over the dial to point the number of the station wanted, the tongues of the relays being now in contact to the right. A cam fixed appropriately to a small wheel engaging with the step-by-step toothed gear, and at a different angle for each station, closes a local circuit and causes the bell to ring in the station called by coming over to its proper position after the requisite number of depressions of key B. The bells in the other stations are not then actuated. At the same time the armature of a second electromagnet in these stations is held over, and cuts their telephones and keys out of circuit. After a conversation is finished, the positions of the needles at all the stations having meanwhile intimated that the circuit is engaged, the key B at either of the two stations that have

extending from 1896 to 1899 tend to show that the motion is mostly due to viscosity of the glass bulb, a gradual increase in size taking place even under an excess of pressure inside the bulb corresponding to the 2 or 3 cm. column of mercury.

One explanation of the phenomenon is based on the supposition that there is a film of water between the mercury and the glass, and that there is a slow viscous transference of water from one side of the mercury column to the other. Supposing the ordinary laws of viscosity to hold, calculation gives the thickness of this film as much below the diameter of the molecule of water.

Experiments extending over one year were conducted on the rate of fall at practically constant temperature, and also at constantly and definitely varying temperatures, the mercury column rising and falling in the tube at an average rate of about 1 cm. in 10 secs. for 3,000 seconds. Experiments were also made with different sizes of bulbs and stems and different lengths of mercury columns, and the author concludes from the results that there can be no doubt that the cause of motion is the volume viscosity of the bulb. In the case of two different tubes the rates of fall were practically constant for the four years during which the experiments lasted. J. B. H.

988. *Conductivity, Specific Gravity, and Surface Tension of Aqueous Solutions of Potassium Chloride and Sulphate.* **J. Barnes.** (Nova Scotian Inst., Trans. 10. pp. 49–66, 1898–1899.)—The results of a number of measurements of the conductivities of solutions of potassium sulphate and chloride and of mixtures of these salts are given; the calculated values for the mixtures agree with the experimental numbers for average concentrations not greater than 0·8 normal. Specific gravity and surface tension determinations of the solutions were also made. The results show that the specific gravity of a solution of the mixed salts having an average concentration of about 0·05 to 0·5 normal can be calculated by a formula given. The same holds for the surface tension, the concentration having the values 0·5 to 1·3. T. H. P.

989. *Superficial Tension in Organic Liquids.* **P. Dutoit** and **L. Friderich.** (Comptes Rendus, 130. pp. 327–330, Feb. 5, 1900.)—Investigation of values of the temperature coefficient of molecular superficial energy. This coefficient varies with the temperature in abnormal, but does not do so in normal liquids. For normal liquids this coefficient is not constant for all bodies, and varies within wider limits than have hitherto been observed. Ramsay and Shields' results are generally confirmed. A. D.

990. *Gravity Balance.* **R. Threlfall** and **J. A. Pollock.** (Roy. Soc. Phil. Trans. 193. pp. 215–258, 1899.)—Full description and discussion (cf. 1899, Abstract No. 1630). Quartz thread is found to be slightly viscous about one-hundredth as much so as steel. Experiments on various forms of gravity balance. A. D.

991. *The Law of Partition of Kinetic Energy.* **Rayleigh** (Phil. Mag. pp. 98–118, Jan., 1900) and **S. H. Burbury** (Phil. Mag. 49. pp. 226–[illegible] Feb., 1900.)—Rayleigh takes for his starting-point Maxwell's paper of 1[illegible] (Collected Scientific Papers, p. 718). To this Kelvin and others have [illegible] objections, Kelvin especially having framed a "decisive test case," which holds to disprove Maxwell's law. Rayleigh considers this test case, comes to the conclusion that it is not decisive, and is, in fact, covere[illegible] Maxwell's reasoning.

He then establishes *de novo* the admitted relation $dxdydudv = dx'dy'du'dv'$, or in generalised co-ordinates, $dp_1 \ldots dp_n dq_1 \ldots dq_n = dp'_1 \ldots dp'_n dq'_1 \ldots dq'_n$, when a system passes with conservation of energy from the state in which it is defined by pq, &c., to a state in which it is defined by $p'q'$, &c. We might say it passes from one state to the other *conservatis conservandis*, but in Rayleigh's view, following Maxwell, the energy E is the only *conservandum*. In the notation of this paper $fdxdydudv$ is the number of systems in the "phase" x, y, u, v. It is found that for a single variable the distribution is permanent when f is a function of E. A similar proposition is proved for two variables. The only assumption necessary, says the author, is Maxwell's assumption that all phases of equal energy lie on the same path, *i.e.*, that a system left to itself will sooner or later pass through every phase consistent with the conservation of energy. He does not say whether the same assumption is applicable to past time. The result is obtained, (33) p. 109, that for systems of any number of variables the distribution will be permanent if f is constant throughout the path. But E is constant also. Therefore f is a function of E.

This result being obtained, it is shown that if E can be reduced to a sum of squares—

$$E = q_1^2 + q_2^2 + \&c.$$

then—

$$\overline{q_1^2} = \overline{q_2^2} = \&c.$$

He maintains that the kinetic energy can always be reduced to a sum of squares. As to this, Kelvin had said the reduction to a sum of squares leaves the several parts of the whole with no correspondence to any defined or definable set of independent variables. This objection and also an objection made by Bryan are considered.

No express reference is made to any encounter or mutual action between the systems whereby any system may be made to change its path. He accepts the extreme consequence of his theory, if proved, namely, that the law of equal partition of kinetic energy must apply to all states of matter (see p. 115).

S. H. Burbury in referring to Rayleigh's article asks for a formal enunciation of the law, expressing what conditions are essential besides that of stationary motion. An example is given to show that stationary motion alone is not sufficient. Reference is then made to the kinetic theory of gases in which the law of equal partition of energy is indeed proved, but only, according to Boltzmann, on a certain hypothesis. And the question arises whether Boltzmann's hypothesis is true. In this writer's opinion Rayleigh's argument (p. 109 of the Phil. Mag., January, 1900) requires some assumption beyond Maxwell's assumption on which it is avowedly based. Also there may, he says, be other constants besides the energy which alone is used as constant by Rayleigh. Further, does not Rayleigh's method prove too much? If it holds, the consequence follows, according to this writer, that not merely the equal partition of energy, but the law of distribution of velocities, ϵ^{-hE}, must hold for all states of matter. S. H. B.

992. *Flux of Mechanical Energy.* **V. Volterra.** (N. Cimento, 10. pp. 257–259, 1899. Paper read before the Meeting of the Società Fisica Italiana, Sept. 21, 1899.)—The author refers to Poynting's law of the flow of energy in the electromagnetic field: also to the researches of Wien on the localisation

space and in part of space occupied by matter, in which the only forces acting are the Newtonian attractions, and the elastic forces, and he propounds the question whether it is possible to represent the flow of energy in all space on the assumption that no transformation into other forms of energy takes place. And this question is answered in the affirmative, namely, that it is possible so to represent it by means of quantities referring only to the point considered.

The energy of the Newtonian attractions due to a system of masses invariable in position can be put in the form $F^2/4\pi$ per unit of volume, where F is the force per unit of area. That is on the hypothesis on which the Newtonian system is based, namely, that of instantaneous action at a distance. If the masses at given positions, instead of being invariable, change with the time, as will be the case if the masses are in motion, a corresponding expression must hold for the variations of these masses. The author takes a new vector I denoting the time variation of F, and finds for the corresponding flux of energy the expression $-\frac{1}{4\pi}f\,I$, where f is the projection of F on the direction of I. He next considers the flux of kinetic energy and that of the elastic forces. The results obtained are as follows :—

The flow of mechanical energy at any point is the resultant of three vectors : (1) The vector I, denoting the rate of change of the Newtonian force multiplied by $U/4\pi$, U being the Newtonian potential ; (2) The vector V, representing the velocity of motion of matter at the point considered, multiplied by $\rho\left(\frac{V^2}{2} - U\right)$, ρ being the density ; (3) The product of V and the vector T, which represents the elastic tension.

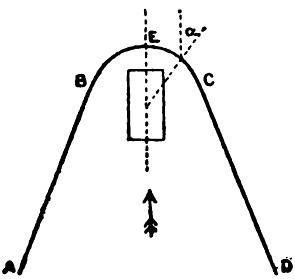
Finally he considers the motion of a spherical mass as equivalent to a magnetic element magnetised in direction of the motion. S. H. B.

993. *Range of Observable Phenomena.* **G. J. Stoney.** (Roy. Dublin Soc., Proc. 9. pp. 79–96, 1899.)—The author classifies the various measurable distances under four groups, as stellar distances, planetary intervals, laboratory measures, and molecular quantities respectively. Each of these stands to the next in the ratio of 10^{10} to 1. The uttermost region of the visible universe accessible to our telescopes is probably 10^{21} m. away. Light takes some 100,000 years to reach us from there, and, when the white spot flared up in the nebula of Andromeda some time ago, we were probably witnessing an occurrence which happened during the neolithic period. Light, by its wonderful speed, brings these enormous distances within our grasp. It also brings us into touch with extremely minute intervals by the smallness of its wave-lengths. The smallest distances with which we can even theoretically deal are larger than 10^{-19} m., and comprise the intervals concerned in events within atoms. A further subdivision is, to us, meaningless. The known universe, then, is comprised between the limits of ultra-stellar remoteness and infra-molecular proximity. Large as the range is, it might be infinitely larger in both directions. Mapped out as it is by the author, it resembl nothing so much as an absorption band in a spectrum, representing the portion of the material universe which happens to be accessible to hu faculties. E. 1

994. *Resistance of Air to Projectiles.* **P. Vieille.** (Comptes Rendus, 13 285–238, Jan. 29, 1900.)—Experiments of Mach and Boys have shown

projectile moving in air causes an abrupt disturbance, which accompanies the projectile as a ripple A B C D.

The normal velocity of the parts A B and C D is equal to the velocity of sound, while that of E is equal to the velocity of the projectile. The author considers the motion of a projectile so large that the curve at E may be con-



sidered flat, and calculates the difference in pressure between the two sides of the ripple from the formula—

$$V = \sqrt{\frac{1\,P_0}{\rho_0\,2}\left(2\,m + (m+1)\,\frac{P_1 - P_0}{P_0}\right)}$$

Where V equals the velocity of the projectile, ρ_0 and P_0 are respectively the density and pressure of the air at rest, P is the pressure on the side of the ripple near the projectile, and m is presumably the ratio of the specific heats. The equation may be applied to the motion of the large *projectiles de rupture de la Marine*. Some results are given below :—

Speed of Cylindrical Projectile.	Observed Resistance in kgs. per sq. cm.	Theoretical Resistance.	Difference.
400 m.	1·25	1·58	0·33
600	3·26	3·78	0·52
800	6·23	6·85	0·62
1,000	10·15	10·81	0·66
1,200	15·01	15·64	0·63

Practice and theory agree so well up to 1,200 per second that it is interesting to calculate the resistances experienced and the temperatures attained by a body moving with high velocities as follows :—

Speed.	Resistance.	Temperature.
1,200 m.	15·64	680°
2,000	43·8	1,741
4,000	175·6	7,751
10,000	1,098	48,490

Without attaching absolute values to the numbers they give an idea of the way in which high temperatures may be attained by meteorites. A. G.

995. *Study of Upper Atmosphere with Kites and Balloons.* **L. Teisserenc de Bort.** (Soc. Franc. Phys., Séances, 3. pp. 126–135, 1899.)—This method of meteorological inquiry has been previously noticed in Abstracts Nos. 1642 and 1643 (1899). The present article contains a review of previous work, but new interest attaches to the statement that in September, 1899, observations were made at an altitude of 4,800 metres, the highest hitherto attained by any form

of kite. Considerable success has been attained in improvements permitting the ascent of small balloons during violent gales, even when wind had a velocity of 14 metres per second. These captive balloons have attained much greater altitudes than the kites, but of course difficulty was encountered on account of heating action of sun. By working at night by moonlight over 120 balloons have been launched, by means of which the curves of temperature and pressure have been automatically registered at a height of 13,000 metres on twenty-four occasions, at 14,000 metres eight times, and at 15,000 metres three times. The chief conclusions derived from the discussion of the results are: (1) The differences of temperature from one day to another may be greater at altitudes of 7,000–8,000 metres than near the surface of the ground; (2) That the temperature decreases much more quickly in the neighbourhood of regions of depression, being in some cases as much as 0·90° C. for 100 metres. C. P. B.

996. *Elastic Waves in Stone.* **M. P. Rudzki.** (Acad. Sci. Cracovie, Bull. 40. pp. 373–384, 1899.)—In an earlier paper the author has shown that pressure or stratification (or both causes together) produces such a condition in stone that it cannot on a large scale be considered isotropic. The present paper is mathematical, and an endeavour is made to obtain an idea of the form of the wave surfaces in granite when subjected to pressure. There are not sufficient experimental data to work out the subject fully, and so arbitrary values are given to certain constants. The author concludes that there are no grounds for assuming that torsional and dilatational waves are separated in such stones as granite, gneiss, &c. A. G.

997. *Dynamical Criticism of the Nebular Hypothesis.* **F. R. Moulton.** (Astrophys. Journ. 11. pp. 103–130, March, 1900.)—In this article the author discusses at some length the bearing of modern dynamical treatment on the various problems involved in the nebular theory of cosmic evolution enunciated by Laplace. The various criticisms put forward may be grouped into three categories: (1) Comparisons of observed phenomena with those which result from the expressed or implied conditions stated by the hypothesis; (2) Discussions of the question whether the supposed initial condition could have developed into the existing system; (3) Comparisons of these properties of the initial system with the one now existing, which are invariable under all changes resulting from the action of internal forces.

Under the first section of the discussion it is pointed out that the fact that the planes of the planetary orbits presenting considerable variations among themselves, and also that four satellites revolve in planes making practically right angles with the average plane of revolution of the system, are in direct contradiction with one of the chief deductions from the hypothesis. Other objections concerning observed phenomena are the unaccountable and suspiciously irregular distribution of the masses of the planets, and the unexplainable anomaly of the motion of the inner ring of Saturn.

The objections considered under the second category are that the light elements would have escaped from the mass; that matter would have be detached *continuously* instead of in rings at rare intervals; that if a ring we contracted into a planet except an infinitesimal remainder distributed alo its path, the process of aggregation could not complete itself; that t gravitation in the masses occurring in the rare media would be so feeble t they would seldom come in contact, and that *Roche's limit* and a similar n

[redacted]

criterion show that fluid masses of the density which must have formerly existed would be disintegrated by the disturbing action of the sun.

In the third section of the inquiry the question of conservation of moments of momentum is alone considered, but the results obtained are in such discordance with those required by the hypothesis as to indicate that the original nebulous mass, so far from being in any sense *homogeneous*, was *heterogeneous* to a degree hitherto considered improbable. Involved in the validity of the above statements is the question of the age of the earth, which has been calculated on the theory of the sun's contraction from a gaseous sphere arranged in concentric envelopes. C. P. B.

998. *Silicon in Stellar Spectra.* **J. Lunt.** (Roy. Soc., Proc. 66. pp. 44–50, March 8, 1900.)—Gill had called attention to three unknown lines in the spectrum of β Crucis (Roy. Soc., Proc. 65. p. 205), and McClean had also recorded them in his measures. Being engaged in obtaining a comparison spectrum of oxygen, the author used a tube containing CO_2 and excited it from a powerful 18-inch coil with four large jars and an air-gap in the secondary circuit. From this and an argon tube, spectra were obtained showing three lines which coincided with the three lines previously noted by Gill as unknown. Trying many different tubes it was found that with a discharge of low intensity the spectrum of the gas was obtained, while on passing a more intense discharge the gaseous spectrum disappeared, and was replaced by that of calcium and oxygen, together with the new lines. This pointed to the disintegration of the glass of the tube as the source, and trial of the spark between glass electrodes proved this to be correct. Finally a tube was made without capillary and filled with gaseous SiF_4, and this, showing the lines, proved conclusively that the three lines were due to silicon. Their wave-lengths are λ4552·79, 4567·09, and 4574·68.

The paper closes with a discussion of the application of this spectrum of silicon as a criterion for the determination of relative stellar temperatures.

C. P. B.

999. *Spectra of Polar Auroræ.* **Paulsen.** (Comptes Rendus, 130. pp. 655–656, March 5, 1900.)—Working in Iceland with two spectrographs, one with a quartz train, the author has obtained several photographs of the spectrum of the aurora borealis showing twenty-two lines, sixteen of which are new. Their positions are as follows:—

Strong lines: λλ337, 358, 391, 420.

Feeble lines: λλ353, 371, 376, 381, 393, 397, 402, 406, 412, 417, 422, 432, 436, 448, 449, 456, 463, 470.

Other lines have been traced between λ337 and λ250, but are too feeble for measurement. C. P. B.

REFERENCE.

1000. *Viscosity of Solutions.* **R. Hosking.** (Phil. Mag. 49. pp. 274–286, March, 1900.)—The work is experimental, and has for object the attainment of a knowledge of the data for some typical solutions up to at least the standard of accuracy reached by Thorpe and Rodger for the commoner liquids. The types chosen are solutions of sodium chloride of 1, 5, 10, and 20 per cent., representing electrolytes; and solutions of cane sugar of 1, 5, 10, 20, and 40 per cent., representing non-electrolytes. Absolute values of the viscosity are given over a range of temperature from 0° to 90°.

A. G.

LIGHT

1001. *Electromagnetic Theory of Light. I. Geometrical properties of the wave surface. II. Reflection and refraction at the boundary of crystals.* **A. McAulay.** (Phil. Mag. 49. pp. 228–242, Feb., 1900.)—The author begins by the statement that in a non-magnetic medium: (1) The electromagnetic displacement D is the exact mathematical equivalent of Fresnel's displacement. (2) The electromagnetic M.M.F., H, or the magnetic induction B, is the exact mathematical equivalent of McCullagh's displacement. (3) The electromagnetic E.M.F., E, is the exact mathematical equivalent of Kelvin's displacement.

In the second and third cases the mathematical equivalence extends, not only to the properties of plane waves within a medium, but also to the boundary conditions between two media. This is true in the first case also, in so far that the laws of reflexion and refraction at the boundary of isotropic transparent media, which result from the two theories, are the same. The four vectors, D, E, B, H, each divided by the square root of the energy per unit of volume, are denoted by δ, ϵ, β, γ. The ray velocity is ρ, the wave velocity is σ. Four geometrical propositions are proved in Part I. relating to these vectors. Proposition I. states that the loci of the extremities of these four vectors each drawn from a point O are ellipsoids with common centre O. He calls them the D-oid, E-oid, B-oid, and H-oid. Proposition II. states that the D-oid and E-oid are reciprocal polars, and the B-oid and D-oid are also reciprocal polars.

Proposition III. asserts that if the six vectors be arranged round a circle in the order δ, γ, ρ, ϵ, β, σ, each one is the vector product of its two next neighbours. Proposition IV. asserts that ϵ and γ are in direction conjugate to one another with regard to the E-oid and the H-oid. Similarly δ and β are conjugate to one another with regard to the D-oid and B-oid. The method employed in the proof of these propositions is that of quaternions.

Part II. treats of the reflexion and refraction at the surface of crystals, based on a theorem of W. Hamilton. There are generally at the surface five rays, viz., the incident ray, and two refracted and two reflected rays. The M.M.F.'s of these rays are denoted by H_1, H_1', H_2', H_1'', H_2''. The corresponding vectors of ray velocity are ρ, ρ_1', ρ_2', ρ_1'', ρ_2''. Hamilton's theorem is that if we suppose mechanical forces H, —H', —H_2', H_1'', H_2'', to act at the points whose vector co-ordinates are ρ, ρ_1', ρ_2', ρ_1'', ρ_2'', they will reduce to a couple whose plane is parallel to the face. The theorem holds only when both media are non-magnetic. S. H. B.

1002. *Optical Constants of Metals.* **J. Koenigsberger.** (Deutsch. Phys. Gesell., Verh. 1. 14. pp. 247–252, 1899.)—The author finds that the optical constants of metals (the refractive index and absorption) are independent of temperature. The metals used were: gold, silver, platinum, iron, nickel, and copper, in the forms of thin films deposited on glass. The range of temperature extended up to 360° C.

According to Maxwell's theory the index of absorption is equal to the

product of the electric conductivity, the velocity of light, and the wave-length in the medium. The electric conductivity varies very greatly with the temperature, and therefore the index of absorption ought to vary accordingly. The author accounts for the disagreement by supposing that the electric conductivity as ordinarily measured is not the same as the conductivity for electric waves whose period is comparable with the wave-length of light. The conductivity according to this assumption may be divided into two parts, the one depending on the temperature satisfying slow electric oscillations, and the other independent of the temperature satisfying very rapid oscillations. The conductivity for Hertzian waves of about 4 metres wave-length has been found to be the same as for continuous currents. Rubens and Nichols have found, however, that the reflection and absorption of metals increases very greatly for long infra-red waves, the increase being partly dependent on the temperature.

The paper contains also a mathematical consideration of the subject.

J. B. H.

1003. *Metallic Reflection.* **E. Hagen** and **H. Rubens.** (Ann. d. Physik, 1. 2. pp. 352–375, Feb., 1900.)—The authors determined the reflective powers of various metals and of glass mirrors for the various rays of the visible spectrum by a photometric method. The substances were put into the shape of concave mirrors, and the real image of a strip of incandescent platinum was formed by reflection close to the object, and compared with the latter by a spectro-photometer. As a general rule, the reflective power of metals increases with the wave-length of the light. This is of course especially the case in gold and copper. Thus the reflective power of gold for rays of wave-length 700 is the same as that of silver. As regards speculum metals, those of Rossé, Brashear, and Schroeder, all have about the same reflective power, which is equal to that of nickel. Brandes and Schuenemann's nickel-iron alloy is not highly reflective, but exceedingly durable, and takes a fine polish. Some of Mach's aluminium-magnesium speculum metals have a very high reflective power, which approaches that of silver. (See also 1900, Abstract No. 463.)

E. E. F.

1004. *Refraction in Crystals.* **L. T. More.** (Phil. Mag. 49. pp. 262–274, March, 1900; read in part to the American Mathematical Society, August, 1899.)—In doubly refracting media light breaks up into two parts which follow different paths unless the light traverses a path coinciding with the optic axis of the crystal, or unless the path coincides with the major or minor axis of the elliptic section of the wave surface. That these are only two special cases of an infinite number in which the paths of the ordinary and extraordinary coincide was first shown by Brace.

The geometrical construction for obtaining the coincidence of the two rays follows at once from Huyghen's principle. Suppose O is the centre of the principal section of Fresnel's wave surface, and suppose any ray OEC cuts the circle in C and the ellipse in E. If we draw tangents at C and E these will meet in a point S. If now OS be taken as the surface of the crystal, any ray which is incident on it at such an angle as to make the ordinary ray pass along OC will have the ordinary and extraordinary rays coinciding in OCE.

In the present paper the author considers mathematically the locus of S, the intersection of the tangents. The equation is of the eighth degree, and represents a curve symmetrical about the axes. Diagrams in the paper show the

form of the curves for the three principal sections of a biaxial crystal, and also for both a negative and positive uniaxial crystal. The mathematical results of the paper are applied to determine a section of Icelandspar and one of Aragonite which will give three pairs of coincident ordinary and extraordinary rays. In order to obtain these in practice it is necessary to immerse the crystal in a suitably refracting medium, as some of the coincident rays are beyond the critical position when the crystal is in air.

J. B. H.

1005. *Paris Exhibition Telescope.* **J. N. Lockyer.** (Nature, 61. pp. 178–181, 1899.)—Several articles have been written on this instrument, giving isolated details; the present one is more complete. It is hoped that the magnifying power employed under good observing conditions will show the moon's surface as if it were only 67 kilometres distant, so that any feature more than 1 metre square may be detected. The focal length is 100 metres (328 feet) or about 4½ times that of the Yerkes telescope. The glass mirror, 2m. diam., was cast at the Jeumont glass works under the direction of Despret, and has a thickness of 30 cm., weight 3,600 kilos. The advantage of reflecting the light from a celestial object from the mirror of a siderostat driven by clockwork into the fixed telescope is manifest in an instrument of this size, as a dome 340 feet in diameter would have been necessary, the mechanical difficulties in constructing and moving which would have been enormous. Besides this, the use of the siderostat ensures greater stability, and saves the observing astronomer much unnecessary fatigue and loss of time in that he has never to change his position of observation.

The pedestal for the siderostat is 8 metres high and 8 metres long, resting by six screws on a stone slab 1·70 metres high. The north part of pedestal supports the polar axis with driving and position circles, and also the sliding pivot for the declination circle. The mirror and cell together weigh 6,700 kilos. The cell of mirror is lined with felt and the weight of the mirror is distributed by a carefully adjusted system of levers and counterpoises, and in addition, at the base, the whole framework rests in a basin of mercury, the quantity of which is adjusted so as to float about nine-tenths of the whole movable weight. The total weight of the siderostat is 45,000 kilos.

The telescope proper is provided with two object glasses, one for visual work, the second for photography. Each is 1·25 metres in aperture. The glass for these was made by Mantois, and the final optical grinding and finishing is by Gautier. The flint lens weighs 360 kilos, the crown 220 kilos. The telescope tube is of sheet steel, 2 mm. thick, 1·50 metres in diameter, and weighs 21,000 kilos. It is supported horizontally on eight cast-iron brackets resting on stone pillars. Both objectives are mounted on the same carriage, by which either can at once be placed in line with the tube. The eyepiece tube is double, the interior part being rotated by clockwork, so that the movement of the stars is neutralised. Illustrations are given showing the various parts to scale.

C. P. B.

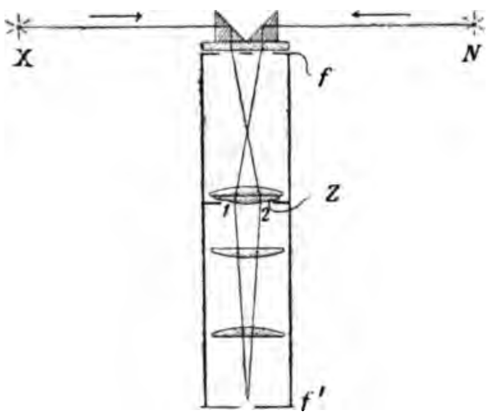
1006. *Adjusting Photographic Telescopes.* **G. Meslin.** (Comptes Rendus, 130. pp. 495–496, Feb. 19, 1900.)—Lippmann has described a convenient method of focussing a collinator by interposing a pair of glass plates in the path of the transmitted beam (Journal de Physique, p. 594, 1899), and the present paper is an extension of the idea for adjusting the photographic plate at the focus of a telescope.

The advantage is that the adjustment is recognised by the disappearance

of a duplicated image instead of the more or less sharp appearance of the single image as usually examined. The procedure is to hold an opaque screen in the path of the light from the objective, then while the ground glass is exactly at the correct focus, a single image will be seen, but if it is away from the conjugate focus, there will be a duplication of the image, caused by the light from the two parts of the objective not masked by the interposed opaque screen. C. P. B.

1007. *König Spectro-photometer.* **F. F. Martens.** (Deutsch. Phys. Gesell., Verh. 1. 15. pp. 280–284, 1899.)—The author describes certain improvements made in König's spectro-photometer of 1885. The telescope is movable about a horizontal instead of a vertical axis, and certain disturbing reflections are avoided. E. E. F.

1008. *Prism Photometer.* **F. F. Martens.** (Deutsch. Phys. Gesell., Verh. 1. 15. pp. 278–279, 1899.)—The two beams of light to be compared enter by the two apertures in the diaphragm *f* (see diagram). Between *f* and a second opaque diaphragm *f′* a twin prism Z with some lenses is so arranged that the two diaphragms *f* and *f′* are projected upon each other, and that the edge of the twin prism is seen sharp from *f′*. The observer thus sees the two halves



of the prism each through a different aperture of the diaphragm *f*. This comparison apparatus can be used in connection with various measuring apparatus. It may be mounted on an optical bench. It fulfils all the conditions laid down by Weber and by Lummer and Brodhun for instruments of photometric comparison. For each field only receives light from one of the sources, the two fields are separated by a perfectly sharp line, and that line disappears entirely at equal luminosity. E. E. F.

1009. *Diffraction in Optical Instruments.* **K. Strehl.** (Zeitschr. Instrumentenk. 19. pp. 364–371, Dec., 1899.)—The author points out the various fallacies occasioned in the construction and use of optical instruments by the neglect of certain principles of diffraction. Geometrical and physical optics look upon light from two diametrically opposite points of view. Geometrical optics deal with the "ray," and consider it as being propagated in a straight line. In reality, the greater the efforts that are made for isolating a ray, the more does it tend to disappear. The diffraction theory starts from the wave

surface, and assumes that light is propagated primarily in spherical wave surfaces. Its smallest element is a portion of luminous energy evenly distributed over a very small surface. The "cone of rays" is a fiction of geometrical optics, which leads to such fallacies as that the apparent brightness of fixed stars increases with the square of the aperture, and is independent of the magnification. In the construction of achromatic objectives, the concentration of the light of two different wave-lengths is erroneously considered to be of paramount importance. The author shows that the so-called apochromatic lenses are nothing but objectives with a strongly diminished secondary spectrum. It is only when extremely great focal lengths or small apertures are used that we have truly apochromatic lenses.

E. E. F.

1010. *Fringes of Mixed Plates.* **C. Fabry.** (Journ. de Physique, 8. pp. 595–599, 1899.)—Fringes of mixed plates are observed in a transmission apparatus for Newton's rings, in which the thin layer, instead of being a layer of air, consists of two different media, such as a layer of air interrupted by numerous drops of water. There is interference between the light which has traversed the air and that which has traversed the water. If there is normal incidence, and n is the refractive index of the water, and e the thickness of the layer, the difference of path between the two rays is $(n-1)e$. We shall therefore have a system of rings with a white centre, the maxima of which are defined for a wave-length λ by the equation $(n-1)e=\lambda$. This is the classical theory, but the author points out that it is incomplete, and proceeds to supplement it by the modern theory of diffraction. He shows that the centre is not necessarily white, but may be made either white or black according to the illumination. The theory of the rings with a white centre may be derived from that of the rings with a black centre by simple reversal, and the aid of the case where the rings are invisible. E. E. F.

1011. *Reciprocity in Diffuse Reflection.* **Rayleigh.** (Phil. Mag. 49. pp. 324–325, March, 1900.)—Commenting upon Wright's conclusion that "a law for the intensity of reflected scattered light cannot be symmetric in reference both to the angle of incidence and the angle of emergence," the author says that that conclusion is in contradiction with a fundamental principle of reciprocity of such generality that escape from it is difficult. He thus applies the principle to the present case:—

"Suppose that in any direction (i) and at any distance r from a small surface (S) reflecting in *any manner* there be situated a radiant point (A) of given intensity, and consider the intensity of the reflected vibrations at any point B situated in direction ϵ and at distance r' from S. The theorem is to the effect that the intensity is the same as it would be at A if the radiant point were transferred to B. The conclusion follows that whatever may be its character in other respects, the function of i and ϵ which represents the intensity of the reflected scattered light *must* be symmetrical with respect to these quantities.

"The actual departures from the reciprocal relation found by Dr. Wright were not very large, and they may possibly be of the nature of experimental errors. In any case it seems desirable that the theoretical difficulty in accepting Dr. Wright's conclusion should be pointed out." E. E. F.

1012. *Kirchhoff's Law and Electrically Glowing Gases.* **M. Cantor.** (Ann. d. Physik, 1. 3. pp. 462–465, March, 1900.)—The light from an arc lamp

falls upon two mirrors placed vertically one below the other, and having their planes vertical and normal to each other. The lower mirror reflects the beam into a vacuum tube and out at the other end, where it is received on another mirror, and reflected back again through the tube, finally entering a spectroscope provided with a Vierordt double slit. The upper mirror reflects the beam direct into the spectroscope. Of the two beams thus compared, one traverses the glowing gas in the vacuum tube twice, while the other does not. The observer is, therefore, able to determine whether the first beam is perceptibly absorbed by the glowing gas. Allowance must be made for illumination by the glowing gas itself. The author finds that there is no perceptible absorption. As by Kirchhoff's law the ratio of the emission to the absorption equals the emission of a black body at the same temperature, the glowing gases should have an extremely high temperature. But since they have not, Kirchhoff's law does not hold for electrically glowing gases.

E. E. F.

1013. *Spectrograph.* **J. Hartmann.** (Zeitschr. Instrumentenk. 20. pp. 17–27, Jan., and pp. 47–58, Feb., 1900.)—This paper deals with investigations which have been conducted during the last two years at Potsdam preparatory to building two spectrographs to be used in conjunction with the large refracting telescope in the observatory at Potsdam for the photography of stellar spectra.

The points dealt with are: (1) Choice of objectives for collimator and camera; (2) Relative light intensity from simple and compound prisms; (3) Requisite size of prisms; (4) Testing and adjusting the apparatus; (5) Sliding diaphragms for the slit for stellar spectrography.

The conditions to be satisfied by the collimator objective are just those which an astronomical objective fulfils, namely, absence of spherical aberration and good achromatism for rays from a point on or near the axis. For the camera objective the conditions are different. The lens must be a very wide angle lens and must have no spherical aberration. The achromatism, on the other hand, is of secondary importance, as the photographic plate may be set at an angle. If the lens is made of two glasses achromatised for two wave-lengths, then the focal length is a minimum for the wave-length midway between these two in the spectrum. The photographic plate may therefore be set up perpendicular to this ray, and the lenses may be so chosen that when this ray is in focus all the rest of the spectrum is practically in focus.

With compound prisms it is generally assumed that greater dispersion can be obtained than with simple prisms with the same loss of light, owing to the diminished number of surfaces between glass and air through which the light has to pass. The author here shows, however, that this increase of light is lost in the increase of thickness of the glass and in the less favourable angle of incidence which it is necessary to adopt with the compound prism.

With regard to the size of the prisms, the author finds that besides the saving in weight and cost when the prism is made smaller so as not to catch the whole of the parallel circular beam from the collimator, there is also a gain in brightness of the spectrum, due to the diminished absorption in glass. The reduction must not be carried too far, however. The best conditions are obtained when a segment of the circular beam subtending at the centre an angle of 80° passes the edge of the prisms. No light, however, must pass the base edge.

For an account of the methods of testing the lenses and prisms and the

1014. *Rotatory Power of Active Valeric Acid.* **P. A. Guye** and **E. Aston.** (Comptes Rendus, 130. pp. 585–588, Feb. 26, 1900.)—The anomalous change in specific rotatory power exhibited by amyl alcohol (see 1898, Abstract No. 867) in its passage from the liquid to the vaporous state, is not shown by all active substances which, like amyl alcohol, are polymerised when in the liquid state. Thus, the authors find that the rotatory power of valeric acid decreases continuously as the liquid is heated and finally vaporised. Further, in aqueous solution, the specific rotation of valeric acid does not change with the concentration, and is, besides, considerably greater than the value in ethylene bromide, the rotatory power in the latter case varying greatly with the concentration of the solution; hence it follows that valeric acid, like amyl alcohol, is composed of a mixture of simple molecules ($C_5H_{10}O_2$) and of molecular complexes $(C_5H_{10}O_2)_n$, the former having a higher optical activity than the latter. The fact that the specific rotation of amyl alcohol shows diminution when the liquid is vaporised, whilst that of valeric acid exhibits no such behaviour is due to two causes: (1) As shown by Ramsay and Shields, in the case of the primary alcohols of the fatty series, the action of heat in resolving the complex molecules is very marked, whilst with the fatty acids such action is scarcely appreciable. (2) The vapour density of amyl alcohol is about normal, while that of valeric acid indicates the presence of a large proportion of complex molecules; in the latter case, then, the specific rotation of the simple molecules is masked by that of the more numerous molecular complexes. T. H. P.

1015. *Kerr Effect.* **F. J. Micheli.** (Ann. d. Physik, 1. 3. pp. 542–565, March, 1900.)—The Kerr phenomenon in cobalt and nickel is disturbed by the presence of surface contaminations even in very minute quantities. In these metals, and also in steel, the critical angle of incidence is lowered by impurities. Even in the case of the cleanest mirrors, the magneto-optic phenomena in nickel and cobalt cannot be represented by one constant only. The introduction of a second magneto-optic constant still leaves distinct differences between theory and observation. These differences are partly explained, and can to a certain extent be calculated, by assuming that the mirror is not magnetised in a perfectly homogeneous manner. When that is done, it is found that the "equatorial" magnetisation produced by a field parallel to the mirror and to the plane of incidence is in the case of nickel and cobalt somewhat less on the surface than in the interior, even when the thickness of the surface layer does not exceed $\frac{1}{15}$ of the wave-length of light, or $\frac{1}{50}$ in the case of cobalt. E. E. F.

1016. *Absorption of Light in a Magnetic Field.* **A. Righi.** (Journ. de Physique, 8. pp. 608–610, 1899. From Bologna, Accad. Scienze, May 28, 1899.)—The acquisition of a large Rowland grating has enabled the author to proceed further in the study of the properties of the hyponitrite of sodium and of sodium vapour, traversed by a beam parallel to the magnetic lines of force. The absorption lines of hyponitrous acid which undergo a sensible change owing to the action of the field are distributed in two groups, one of them situated between the components of the D line, and the other between 5920 and 5924. When the field is made, these lines become blurred and get mixed up together in a single band. E. E. F.

1017. *Reciprocity in Magneto-optic Phenomena.* **O. M. Corbino.** (N. ento, 10. pp. 408–419, 1899.)—In the Amer. Journ. Sci. 90. p. 196, 1899,

Sheldon finds a magnetic field created by a bundle of light rays whose plane of polarisation is undergoing rapid rotation; but the author, by several methods which ought to show a much greater effect, entirely fails to confirm this result and explains Sheldon's experiments by various disturbing causes.

A. D.

1018. *Zeeman Normal Triplet.* **W. Voigt.** (Ann. d. Physik, 1. 2. pp. 376–388, Feb., 1900.)—The formulæ obtained by the author for the normal Zeeman triplets are very complicated, and he has hitherto confined himself to a first approximation. The agreement between the theoretical results so obtained and the observations made by Zeeman have encouraged him to pursue the matter to a further approximation, and he thus obtains a theoretical value of the dissymmetry observed in the normal triplet, and quite lately also in the quadruplet. The observed dissymmetry is very slight even in the most favourable case. E. E. F.

1019. *Experimental Work with the Echelon Spectroscope.* **Blythswood** and **E. W. Marchant.** (Phil. Mag. 49. pp. 384–408, April, 1900.)—The first *echelon* grating made in this country, by Hilger, is in the possession of Lord Blythswood, who has been using it at his laboratory at Renfrew, N.B. The present article gives details of the method of mounting, plan of work, and determination of fundamental constants of the instrument. The echelon itself consists of fifteen plane parallel plates of light flint glass, each about 7·5 mm. thick, the consecutive steps being originally set at 1 mm. intervals, but this has now been reduced to 0·5 mm. The whole is mounted on the table of a large goniometer, the telescopes of which have object glasses of 2 inches aperture and 28 inches focus. As approximately monochromatic light must be used the light from the source was first passed through a subsidiary prismatic train, the spectrum given by which was focussed on the slit of the echelons pectroscope, and then, by turning the prisms, light of any desired wave-length could be made to pass into the echelon.

From statements of refractive indices for five wave-lengths given by the glass-makers, the constants in Cauchy's dispersion formula were determined, so that the equation became—

$$u_\lambda = 1·5958 + \frac{8·03 \times 10^5}{\lambda^2} + \frac{1·53 \times 10^{12}}{\lambda^4}$$

The authors then give the theory of the instrument as stated by Michelson (see 1898, Abstract No. 1118), with its application to the present specimen.

They then describe the peculiarities incident to the use of the echelon, and the appearance of the spectra given by it are so unusual as to need some little preliminary study. In general several orders of spectra are visible in the field of view simultaneously, but the spectrum constituting any one order may also be presented under a number of different aspects. There may be a single line, or two lines of equal intensity, or an infinite number of combinations of two lines of varying intensity. These changes are brought about by slight rotation of the echelon, and the most advantageous position is when the plates are *normal* to the incident light.

An illustration is given of the electromagnet used for producing the Zeeman effect it was proposed to study. The pole-pieces are 5 inches square, and the winding such that with a current of 20 amperes, a field of 24,000 c.g.s. units can be maintained across an 8 mm. air-gap, and 40,000 across a 1 mm. gap.

The Zeeman effect considered was that of mercury vapour, and photo-

graphs of the behaviour of the lines λ4858 (blue) and λ5460 (green) were obtained, the exposure varying from ten to twenty minutes with the former, to quite two hours for the latter. Reproductions of these photographs are given in the paper, and show very clearly the multiple groupings with varying fields. With a field of 23,800 the line λ4358 becomes a sextet; the green line, λ5460, becomes a septet with a field of 23,400. Measurements are given for other lines also, λ5768 and λ5790. As the two yellow lines of mercury are produced by relatively simple ionic movements, the value of e/m has been calculated for them from Larmor's equation (1). These values are :—

$$\lambda 5790,\ e/m = 17{\cdot}2 \times 10^6$$
$$\lambda 5758,\ e/m = 18{\cdot}9 \times 10^6.$$

The paper concludes with several suggestions as to advisable modifications in future instruments. The interference of the several orders visible concurrently may be partly remedied by increasing the constant of the echelon, without, however, equally reducing the resolving power. As Michelson suggested, the constant may be reduced by immersion in water, but this would reduce the resolving power to at least one-third of its original value, and therefore is inadvisable. A better proposal is to construct the echelon from *thinner* plates, and using more of them. A useful instrument might be made, say, of thirty plates, 4 mm. thick, set at 0·5 mm. or even 0·25 mm. steps.

C. P. B.

1020. *New Source of Light for Spectrometer.* **C. Fabry** and **A. Pérot.** (Comptes Rendus, 130. pp. 406–409, Feb. 12, 1900.)—After describing and criticising the various methods used for obtaining a suitable source of illumination in work with the spectrometer, the authors give a description of an apparatus in which two pieces of the metal to be investigated are connected to the poles of a battery of secondary cells (60 volts); one of them is made to oscillate and come into contact with the other, and then is immediately withdrawn. At each separation an arc is formed which is quenched and then at once remade at the next contact; as the action is rapid the light appears continuous. In the circuit is inserted a rheostat and a self-induction (primary of a Ruhmkorff coil) to increase the spark at break. The alternating movement is produced by the attraction of an electromagnet on an iron armature. The whole apparatus is enclosed in a vacuum. The spectra thus obtained are almost identical with those from the electric arc; they are much less complex than those produced with the induction discharge with capacity.

It is found that in the case of the green ray of mercury the wave-length of radiation emitted by the spark trembler described is exactly the same as when it is produced by a Michelson's tube or by the mercury arc *in vacuo.* J. J. S.

1021. *Constitution of Yellow Lines of Sodium.* **C. Fabry** and **A. Pérot.** (Comptes Rendus, 130. pp. 653–655, March 5, 1900.)—Michelson has stated that each of the yellow sodium lines is itself made up of two components. The authors, however, noticed in their experiments that although the lines were seen double, the distance between the components continually varied as the intensity of the source of light was altered. This, of course, was in opposition to the idea of their being true multiple lines, and the authors state their reasons for supposing the doubling to be due to ordinary reversal. It is well known that these two sodium lines are very easily reversed, and the *unsteadiness* always noticed in interference work when these radiations are employed may be really attributed to this phenomenon. C. P. B.

1022. *Spectrum of Silicon.* **J. N. Lockyer.** (Roy. Soc., Proc. 65. pp. 449–452, Jan., 1900.)—In 1895 a strange double line was found in the spectrum o the gas distilled from the mineral eliasite. Some time later the same lines appeared in the spectrum of a vacuum tube of hydrogen when worked with a high tension coil with condenser in secondary circuit. This led to the glass itself being regarded as the source of the line, and direct examination of the spark from powdered silica showed the lines plainly. The wave-lengths of these lines are λλ4128·3 and 4131·4, and both are prominent in the spectrum of α Cygni.

In the later experiments a second much wider double was also noticed, having the positions λλ3856·1 and 3862·7, and these also are present in α Cygni.

Still more recent photographs of the spectrum of silicon obtained with the greater tension produced by the Spottiswoode coil, have shown other silicon lines which have also been identified in the spectrum of α Cygni. The more important of these two groups, (*b*) 4089·1 and 4116·4 ; (*c*) 4552·8, 4568·0, 4575·3. Calling the first four lines mentioned group (*a*), it is found that the group (*b*) is characteristic to the conditions of highest temperature, and a diagram is given showing that the three groups persist differently in stars of varying temperatures. Thus the group (*a*) predominates in stars of the type of β Orionis (Rigel), the group (*b*) in stars of the type of ζ Orionis, and the group (*c*) in stars of the type γ Orionis (Bellatrix). C. P. B.

1023. *Reference Points in Spectra.* **M. Hamy.** (Comptes Rendus, 130. pp. 489–492, Feb. 19, 1900.)—The author discusses the advisability of avoiding the use of spectrum lines which have been found to be multiple for standard determinations of wave-length. He suggests as preliminary standards the lines of cadmium at wave-lengths 6438·472, 5150, and 4660, which are, as far as at present known, produced by simple radiations. Experiments are in progress to determine others for intermediate positions. C. P. B.

1024. *Discharge by Röntgen Rays.* **S. Guggenheimer.** (Deutsch. Phys. Gesell., Verh. 1. 15. pp. 272–274, 1899.)—When the air between the two plates of a condenser is ionised by Röntgen rays and a current passes between the plates in consequence, the current increases with every increase of the difference of potential until a certain limiting value is reached, beyond which the current does not increase, whatever be the value of the potential difference. At this point, according to J. J. Thomson, the current strength is proportional to the difference of the squares of the electric force at two points. The author has made some measurements to examine this relationship. The electric force was determined by means of Kelvin's water-jet arrangement. The relation in question was verified in three different series of measurements within about 5 per cent. E. E. F.

1025. *Condensation Nuclei.* **C. T. R. Wilson.** (Roy. Soc., Proc. 65. pp. 289–290. Roy. Soc., Phil. Trans. 192. pp. 403–453, and 193. pp. 289–308, 1899.)—When final volume under adiabatic expansion is less than 1·25 times the initial volume in dust-free air saturated with moisture, no precipitation takes place; when it is more there is some precipitation, with comparatively few drops; beyond 1·38 times the precipitation is abundant. Apparently between 1·25 and 1·38 the precipitation is on nuclei other than the molecules of gas or vapour; beyond that it is upon these molecules. Under Röntgen rays anything beyond 1·25 is equivalent to ordinary air at beyond 1·38, so that

nuclei are formed under the influence of these rays; below 1·25, no precipitation. Water condenses much more rapidly on negative than on positive ions. To cause water to condense on positive ions the ratio must be 1·25 (= fourfold saturation); for negative ions it must be 1·31 (= nearly sixfold saturation). Negative ions must therefore preponderate as condensation nuclei, and if they act as such in the atmosphere a preponderance of negative electricity will be carried down by precipitation to the earth's surface. There is some evidence that such ions are likely to be present under normal conditions in the atmosphere. The limit of expansion at which condensation takes place in "dust-free" air, initially saturated, is identical with that required to make water condense on ions. The number of nuclei is so small as not to be inconsistent with the absence of sensible electrical conductivity in air. But the nuclei do not appear to be ordinary free ions, in respect that an electrical field does not remove them. Possibly the ionisation is developed by the process of producing the supersaturation. [See also Abstracts Nos. 1033 (1898) and 662 (1899).] A. D.

1026. *Röntgen-Ray Photometry.* **H. Boas.** (Deutsch. Phys. Gesell., Verh. 1. 13. pp. 242–244, 1899.)—The intensity and quality of a beam of Röntgen rays is defined by its absolute luminous effect as measured with a fluorescent screen of definite quality at a certain distance from the tube, and by the ratio of the penetrating rays to the absorbed rays. If there is a proportionality between the rate of discharge of an electrified body and the fluorescence, the ionising properties of the rays may be used for determining their intensity. The second or "contrast effect" may be measured by means of a half-shadow polariscope, through which two parts of the screen are viewed, one of them illuminated by the rays direct, and the other by rays which have traversed a platinum plate of definite thickness. E. E. F.

1027. *Absorption of Röntgen Rays.* **E. A. W. Henley.** (Roy. Dublin Soc., Proc. 9. pp. 31–32, 1899.)—Pieces of the substances under investigation were cut in the form of right-angled triangular prisms, which were laid with their bases over a photographic plate. They yielded radiographs of intensity varying according to the thickness, and comparisons with standard prisms could thus be easily made. The organic substances studied were frozen in order to yield hard geometrical figures.

The first comparison was made between muscle and fat of a sheep. As the result of seventeen measurements made on different prints from various negatives, the ratio of the opacities of muscle and fat was found to be 2·5 : 1. The next comparison was made between bone and muscle. In the case of bone, variations occurred according as the specimen contained different proportions of cancellous tissue and of compact tissue. The results given are the mean of all the measurements. The ratio of the opacity of bone to that of muscle was found to be 1·6 : 1, as obtained from eleven measurements. This result, when combined with the previous one, gives the ratio of the opacity of bone to fat as 4 : 1. Hence, the numbers obtained, as representing the relative opacities of bone, muscle, and fat, are 4, 2·5, and 1. E. E. F.

1028. *Radio-activity of Ultra-violet Light.* **P. Lenard.** (Ann. d. Physik, 1. 3. pp. 486–507, March, 1900.)—Kathode rays and other kinds of radiation have the power of imparting electric conductivity to gases, producing nuclei of condensation in them and converting oxygen into ozone. The author points out that similar properties are possessed by ultra-viol

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light. As regards the formation of nuclei, the author has found, since his first experiments in 1889, that the formation of condensation nuclei in steam is not due to ordinary ultra-violet rays, but to rays which are completely absorbed by a layer of air 2 cm. thick. Spectroscopic observations showed the wave-length of these rays to be shorter than those hitherto mapped, ranging as they do from 160 to 190 $\mu\mu$. The source of radiation employed was an induction coil provided with zinc or other terminals. Oxygen, air, and carbonic acid were equally affected, but coal-gas only slightly so, and hydrogen not at all. This is consistent with the fact that hydrogen does not absorb rays filtered through 1 cm. of air.

Electric discharge effects are also produced by these extreme ultra-violet rays. This was proved most strikingly by conveying the gases which had been exposed to the radiation through the space between two concentric brass tubes forming a condenser, and noting their discharging effect. The effect is least in the case of hydrogen, and greatest in the case of carbonic acid. The gas loses its discharging power very shortly after the impact of the radiation. The formation of ozone by these rays is very prompt and easily proved. It is at once evident from the strong smell of ozone in the neighbourhood of the quartz window. All these effects are intercepted by a plate of mica, which does not allow rays of these very short lengths to pass.

The ordinary sources of light do not contain rays of this description, but the electric arc does. The author is strongly of opinion that sunlight contains such rays. They are absorbed in the higher regions of the air, and there they produce the electric conductivity noticed by Elster and Geitel at high elevations. E. E. F.

REFERENCES.

1029. *Refraction through a Prism.* **A. de Gramont.** (Comptes Rendus, 130. pp. 403–406, Feb. 12, 1900.)—A note accompanied by a graphical representation of some of the consequences deduced from the formulæ for refraction through a prism. (See 1899, Abstract No. 1677.) J. J. S.

1030. *Optical Constants of Telescopes.* **H. Kellner.** (Zeitschr. Instrumentenk. 20. pp. 1–17, Jan., and pp. 33–46, Feb., 1900.)—These two papers deal with the different methods used for determining the magnification and the width of field, both real and apparent, in telescopes. Besides describing the methods, their probable errors are also discussed. J. B. H.

1031. *Intensity of Telescopic Vision.* **A. Gleichen.** (Zeitschr. Instrumentenk., Beib. 1. pp. 1–4, Jan. 1, 1900.)—This paper contains a new proof of the fact that the apparent brightness of any surface viewed through a telescope can, under the most favourable conditions, only be equal to the brightness when viewed with the naked eye, and can never exceed it. J. B. H.

1032. *Siderostat and Heliostat.* **M. A. Cornu.** (Astrophys. Journ. 11. pp. 148–162, March, 1900.)—This paper contains a mathematical study of the law of diurnal rotation of the optical field of the siderostat and heliostat. The direction and period of rotation and the angular velocity of rotation at any time are given, and also the conditions for a fixed optical field. The relative advantages of the siderostat and heliostat for different astrophysical purposes are also considered. J. B. H.

1033. *Do Röntgen Rays Promote Cooling?* **A. Amerio.** (N. Cimento, 10. pp. [illegible] 1899).—Mathemactial discussion and experimental enquiry : results

HEAT.

1034. *Specific Heat of Metals, Alloys, and Graphite.* **U. Behn.** (Ann. d. Physik, 1. 2. pp. 257–269, Feb., 1900.)—The specific heats measured were those of antimony, tin, cadmium, silver, zinc, magnesium, graphite, brass, and three tin-lead alloys. The theoretical conclusions arrived at by Richarz are in the main confirmed. Those metals which do not obey the law of Dulong and Petit show a great variation of the specific heat with the temperature, and the cause of both phenomena must be sought in the fact that in them the displacements of the atoms no longer vanish in comparison with the distances between them. This occurs when the atomic intervals are small, and also when the displacements are large. The latter case will occur where the atomic weight is small, since atoms of small weight must attain greater velocities, and hence also greater elongations. In the diagram of atomic volumes in terms of atomic weights, the elements Li, K, Rb, and Cs, occupy a special position on that account. E. E. F.

1035. *Thermal Data for Benzene.* **K. Tsuruta.** (Phys. Rev. 10. pp. 116–122, Feb., 1900.)—From the curve best representing Young's calculated and Griffiths and Marshall's measured values of the latent heat of vaporisation the specific volumes of the saturated vapour are deduced, those of the saturated liquid experimentally found by Young being assumed as correct. The "law of straight diameter" is found to hold satisfactorily, not only from 80° C. to the critical temperature as remarked by Young, but also from 80° C. down to the triple point 5·8° C., though close examination of the results shows this law to be a first approximation only.

The curves for the steam and hoar-frost lines between —1° C. and the triple point judged by the author to best represent the whole of the experimental measurements hitherto published for benzene are then given, and are satisfactorily compared with the approximate theoretically deduced formula—

$$R \log (p_s/p_l) = (F_o/T_o) \log (T/T_o) - \tfrac{1}{2}(c_s - c_l) \log^2 (T/T_o),$$

where p_s and p_l, c_s and c_l are respectively the saturation pressures and specific heats of the solid and liquid phases in contact with the vapour phase at T_o, and F_o is the latent heat of liquefaction at the triple point T_o; the values taken for the constants being—

$$R = 1{\cdot}971/78,\ F_o = 30,\ T_o = 278{\cdot}3,\ c_s = 0{\cdot}2032,\ c_l = 0{\cdot}3350.$$

R. E. B.

1036. *Specific Heats of some Organic Materials.* **G. Fleury.** (Comptes Rendus, 130. p. 437, Feb. 12, 1900.)—Dry cellulose has the specific heat 0·366; cellulose containing 7 per cent. of water, 0·41; dry wool, 0·39; undried wool, with 11 per cent. of water, 0·459; dry leather, 0·357; leather containing 16 per cent. of water, 0·45. The cellulose used was obtained from Berzelius paper and left no appreciable ash. The wool was woven and washed with ether. The leather consisted of chips of thick ox-hide, tanned, as used for saddles; it was not ash-free. T. I

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1037. *Determination of Melting-Points.* **M. Kuhara** and **M. Chikashigé.** (Chem. News, 80. pp. 270–271, 1899.)—The finely divided substance is placed between the two halves of a microscope cover-slip, and is then arranged in a small holder of platinum-foil and hung, together with a thermometer, in a wide test-tube. The test-tube is immersed nearly to its mouth in a sulphuric acid bath, which is heated in the ordinary way. Before melting occurs, the cover-glass appears opaque, but becomes transparent at the temperature of melting, which can be very exactly determined. Test experiments with chloral hydrate, urea, phthalimide and phthalic acid gave good results. The melting-point of the last-named substance, for which varying results have been given by different observers, is found by this method to be 208° for both the crystallised and the powdered acid. T. H. P.

1038. *Latent Heat of Vaporisation.* **W. Louguinine.** (Archives des Sciences, 9. pp. 5–26, Jan., 1900. See also Soc. Franç. Phys., Bull. 139. pp. 1–2, 1899.)—The author has measured the specific heat and heat of vaporisation of certain organic liquids, by the usual apparatus for the method of mixtures, with certain modifications in detail, which are fully described. He finds that acetonitril, propionitril, capronitril, benzonitril, pyridine, piperidine, and acetophenone follow Trouton's law closely, giving for the molecular latent heat ÷ absolute boiling-point values between 19·44 and 20·62. Metacresol gives 22·86, acetic acid, 13·74. From the behaviour of the nitrils the author concludes, contrary to the opinion of Ramsay and Shields, that they consist of simple molecules. R. A. L.

1039. *Absolute Mercurial Thermometry.* **S. A. Sworn.** (Roy. Soc., Proc. 66. pp. 86–91, March 8, 1900. *Note on this paper.* **A. Schuster.** Roy. Soc., Proc. 66. pp. 92–94, March 8, 1900.)—Comparison of six thermometers is made to study the effects of capillarity, and to determine the relation between the readings of thermometers of English flint glass and the hydrogen scale, the latter being done indirectly by comparison with thermometers of "verre dur," and of Jena 16^{III} glass. It was concluded that the capillary constant is a constant not affected by a change in the rate of rise in temperature; also that the conditions of pressure and temperature in a hypsometer are oscillatory, so that all the steam indications of a thermometer are what occur with a receding meniscus; and that the flint-glass thermometers give indications which are practically identical with those of the hydrogen thermometer.

Schuster does not think the first two conclusions true, so that the third, which depends on Sworn's method of reducing all readings to those with a *falling* meniscus, cannot at present be accepted as final. R. E. B.

1040. *Resistance of Platinum and Temperature.* **C. Raveau.** (Soc. Int. Élect., Bull. 16. pp. 410–429, 1899.)—This is an address on platinum thermometry with headings: (1) Constancy of platinum thermometers; (2) Thermometry of precision; (3) Platinum resistance at very high and very low temperatures. It contains a *résumé* of the work done in this connection by different observers. R. E. B.

1041. *Automatic Thermostats of Precision.* **E. Bose.** (Zeitschr. Instrumentenk., Beib. 19. pp. 169–171, 20. pp. 181–183, 21. pp. 189–191, 1899.)—The action of a thermostat depends on variations not only of temperature but also of pressure: for a variation h of the height of a liquid, of total volume v,

apparent expansibility a and compressibility β, in a fine tube of section s, may be produced either by a change of temperature $\tau = hs/va$ or by a change of pressure $\pi = hs/v\beta$: the equation therefore connecting these variations, viz. :—

$$\tau = \pi\beta/a,$$

where π represents the variation, over which we have no control, of the atmospheric pressure during an experiment, may be taken as defining the sensibility of the instrument which thus depends on a/β and not on a simply. Calculations for nine liquids of small specific heat show chloroform and CS_2 as coming next in order to Hg, but with only $\frac{1}{8}$ of its sensibility, while alcohol is at the bottom of the list with $\frac{1}{18}$ of the sensibility of Hg.

It is then shown that it is advantageous to place the regulating part of the thermostat where the interchanges of heat are the greatest and to cover the remainder with felt or other non-conducting coatings; also that the flame should not be too large, and thereby cause quick heating and slow cooling, and thus a maximum of variation, or too small, and thus prolong the period of variation; and it is finally pointed out that defective tightness of joints is responsible for many failures of thermostats. R. E. B.

1042. *Adiabatics of Crystallisation.* **G. Tammann.** (Ann. d. Physik, 1. 2. pp. 275–289, Feb., 1900.)—If in a vessel containing a mixture of solid and fused crystals in a state of equilibrium the pressure is suddenly changed, there will be first a fusion or crystallisation at the expense of the heat furnished by the adiabatic process. This will be followed by a further change of pressure due to the tendency of the system to adapt itself to the new conditions of equilibrium. The latter change of pressure depends upon the efflux of heat, and must therefore proceed much more slowly than the former, which is solely determined by the maximum rate of fusion or crystallisation. If the change of temperature per unit adiabatic change of pressure is greater than for the crystal, or *vice versâ,* and both are greater than the corresponding change in the melting-point, a rapid increase of pressure will be followed by a rapid rise of temperature and rapid fusion. The pressure would then rise further, pass through a maximum, and fall back to the original pressure of equilibrium owing to the efflux of heat. There are four other possible cases. E. E. F.

1043. *Thermokinetic Properties of Solutions.* **L. Natanson.** (Zeitschr. Phys. Chem. 30. pp. 681–704, Dec. 30, 1899. Translated from Rozprawy Wydz. M.P. Akad. Um. w. Krakowie 35. See also Acad. Sci. Cracovie, Bull. 37. pp. 349–359, 1899.)—As in a former paper (see 1899, Abstract No. 1824) the author's 'thermokinetic principle' is applied to the case of a pure substance in contact with a solution consisting of two components on the assumption that there is no friction either at the surface of contact or within either body. The only irreversible process in the system thus consists in the mutual diffusion of the components of the solution. An equation is first formed from consideration of the variations of the kinetic energy (a velocity potential being assumed) and free energy for arbitrary small displacements of the components of the system due to both mechanical and chemical causes, and also of the work done against external pressure and possible gravitative forces, and of the heat dissipated by diffusion without alteration of temperature, account being taken of the conditions to which the system is subject, and 48 simpler equations are deduced from it, one general result of which is that the external pressures must all be normal.

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If the pure substance is the same as one of the components of the solution, much simplification results, and the laws of the possible thermokinetic processes are contained in the equation—

$$E - e + \frac{\partial}{\partial P}PF - \frac{\partial}{\partial \rho}\rho' f + \Psi - \psi + \tau = 0,$$

with

$$E = -(\partial\Phi/\partial t) + \tfrac{1}{2}\{(\partial\Phi/\partial X)^2 + (\partial\Phi/\partial Y)^2 + (\partial\Phi/\partial Z)^2\}$$

and e is a similar function of ϕ, t, x, y, z; Φ, P, F, Ψ being the velocity-potential, density, free energy per unit mass and force-potential of the pure substance at the point (X, Y, Z), and ϕ, ρ, f, ψ, the corresponding magnitudes for this component in the solution at (x, y, z), ρ' being the density of the solution, and τ a function depending on the co-efficient of diffusion and the relative momentum of the other component of the solution.

The equations are then modified for the case of a liquid A separated from a solution with A and B as components by a membrane impermeable by B, and from these it follows that the pressure of the pure liquid A is equal to the partial pressure of A in the solution, so that there must be an osmotic pressure equal to the partial pressure of B in the solution, van't Hoff's theory thus obtaining thermodynamical support. Further, every solution with two components (*e.g.*, mixtures of alcohol and water) may theoretically be considered as having *two* osmotic pressures. R. E. B.

1044. *Radiation of Black Bodies and Platinum.* **O. Lummer** and **E. Pringsheim.** (Deutsch. Phys. Gesell., Verh. 1. 12. pp. 215–230, 1899.)—In continuation of their previous researches [see Abstracts Nos. 761 (1898) and 1482 (1899)], the authors further investigated the distribution of energy in the spectrum of a black body. One of the series of measurements was made with the object of extending the spectrum in the direction of the longer waves. In this case the back wall of the hollow cylindrical space did not consist of a simple partition, but of a bundle of small porcelain tubes. The range of temperatures was over 1,000° (621 to 1646), and the wave-lengths ranged from 1,000 to 6,000μ. Wien's laws, according to which the wave-length of the maximum radiation is inversely proportional to the absolute temperature, and the corresponding maximum energy proportional to the fifth power of the absolute temperature, were confirmed. It was also found that his formula for the distribution of energy in the spectrum

$$E = C\lambda^{-c} e^{-\frac{c}{\lambda T}}$$

renders the observations with fair accuracy, especially at the lower temperatures. At higher temperatures certain systematic differences are observed, which may or may not be due to imperfections in the apparatus. In the case of bright platinum surfaces the calculated energy coincides with the actual energy at the maxima, but falls off more rapidly than the latter at the neighbouring wave-lengths. The maxima of the platinum curves advance with the absolute temperature according to a power somewhat smaller than the sixth.

E. E. F.

1045. *Temperatures of Incandescent Solids.* **O. Lummer** and **E. Pringsheim.** (Deutsch. Phys. Gesell., Verh. 1. 12. pp. 230–235, 1899.)—The laws of radiation for black bodies and for bright platinum place at our disposal a

new means of determining the temperatures of sources of light. The temperature of a perfectly black body is given by the wave-length of the maximum energy of radiation in accordance with the equation

$$\lambda_m T = 2940.$$

If this equation admits of extrapolation, it can be used for determining the temperature of any given black body. Further, we know that the radiation of any body possessing a continuous spectrum can be made equal to that of a perfectly black body by enclosing it in a perfectly reflecting envelope. If, therefore, the temperature of a luminous body is to be found, it should be brought into the centre of a good reflecting hollow sphere silvered on the inside, which allows the radiation to fall through a small opening on to the slit of a spectrobolometer. Then the wave-length of the maximum of energy is determined, and the absolute temperature T is put equal to $2940/\lambda_m$. In practice, the radiating surface will have to be made so large that only itself, and not a portion of the reflecting wall, contributes to the beam measured. Any rise of temperature occasioned by the enclosure may, as a rule, be ascertained by some differential method. Since bright platinum obeys Wien's laws of radiation very closely, it is probable that in many cases the body may not have to be converted into a "black" one. For bright platinum, the constant in the above equation would be 2630, and for most other bodies it would have an intermediate value. E. E. F.

1046. *Apparatus to show Boyle's Law.* **W. J. Humphreys.** (Phys. Rev. 10. pp. 123–125, Feb., 1900.)—The apparatus consists of a U-tube, one limb of which is open, the other closed above and below by three-way glass taps. The volume of air is determined by weighing mercury, and an accuracy of 1 in 1000 is obtainable. R. A. L.

1047. *Molecular Volumes.* **C. M. Guldberg.** (Zeitschr. Phys. Chem. 32. pp. 116–126, Feb. 6, 1900. From the Festschrift der Universität Christiania.) —The author maintains that there exists a value for the volume of a substance, which is independent both of temperature and pressure. It corresponds to the smallest volume which a body can occupy, and may be determined in two ways. When the pressure is gradually increased, the volume tends towards a limiting value which is independent of temperature. When the temperature approaches absolute zero, the volume of a body tends towards a limiting value which is independent of pressure.

First Method.—The characteristic equation may be written in the form : $\frac{p}{RT} = \frac{1}{v-u} - x$, when u and x are unknown functions of volume and temperature. Assuming that, when p is very large and simultaneously v very nearly equal to u, x is not large, the latter may be neglected under these conditions and we have : $\frac{p}{RT} = \frac{1}{v-u}$. Having arrived at the conclusion that u (the value of v for $p = \infty$) is independent of temperature, the author writes $u = v_0$, $\frac{p}{RT} = \frac{1}{v - v_0}$, and shows how limiting values may be calculated between which v_0 must lie. In this way limiting values of v_0 are calculated for a number of organic liquids, from the results of Amagat's compressibility measurements (Annales de Chim. et de Phys. 29, 1893).

Second Method.—The author has previously shown (Christiania Vider

skabsselskabs forhandlinger, 1869) that the thermal expansion of many liquids can be expressed by a formula of the type $\frac{v}{v_0}=f(\tau)$, where f denotes a function of constant form and $\tau=\frac{T}{T_2}$, where T_2 is a fixed temperature for each body. If a and a_0 denote the expansion-coefficients at T and at absolute zero respectively, the author finds that his previous investigations may be summarised by the empirical formulæ: $a=\frac{a_0}{\sqrt{1-\tau}}$, $a_0T_2=0{\cdot}450$. By definition, $\frac{1}{v}\frac{dv}{d\tau}=aT_2$, hence $\log\frac{v}{v_0}=2a_0T_2(1-\sqrt{1-\tau})$. Now for many liquids $T_2=T_1$ (critical temperature), so that $a_0T_1,=0{\cdot}450$. Thus from corresponding values of a and T we can calculate v_0. The author gives a table of the values of v_0 calculated in this way for the liquids referred to above. The table also includes the values of v_0 calculated from formulæ given by de Heen. The two sets agree very well, and the values lie between the limiting values obtained from the compressibilities. It is pointed out that there are liquids for which T_2 is considerably greater than T_1, the value of a_0T_1 being only 0·333 in these cases. The paper concludes with tables which contain the critical temperature, the molecular volume at absolute zero, and the density at the same point, for a large number of liquids. F. G. D.

1048. *Thermal Conductivity of Mixtures.* C. H. **Lees.** (Phil. Mag. 49. pp. 286–293, March, 1900.)—Attempts have been made to express the conductivity of a mixture as : (i.) The weighted mean of the conductivities of the components; (ii.) The reciprocal of the weighted mean of the resistivities of the components. By considering all the available data the author shows that the latter formula is better than the former, but is far from satisfactory. Logarithmic interpolation gives slightly closer results, but is still far from good enough for practical use. R. A. L.

1049. *Corresponding States.* K. **Meyer.** (Zeitschr. Phys. Chem. 32. pp. 1–38, Feb. 6, 1900.)—This paper is an extract from an essay to which the Danish Academy of Science awarded a gold medal. The authoress concludes that (1) the want of correspondence between van der Waals' theory and the results of experiment is not due to uncertainty as to the critical data, but arises from inexactness in the theory itself, (2) the theory may perhaps hold if, in addition to the pressure, volume and temperature of each substance being measured in special units, they are measured from special zeros; that is, that there may possibly be a general characteristic $f(\pi, \omega, \theta)=0$, where—

$$\pi=\frac{p-p_o}{p_c-p_o},\qquad \omega=\frac{v-v_o}{v_c-v_o},\qquad \theta=\frac{T-T_o}{T_c-T_o},$$

p_o, v_o, T_o being special for each substance (as are p_c, v_c, T_c) and not necessarily being 0 as taken by van der Waals.

On van der Waals' theory we may take as units of pressure, density and temperature, their values at any other corresponding points than the critical points, since $p/p'=(p/p_c)\div(p'/p_c)$, . . . and p'/p_c, . . . are constant for corresponding points. In testing the theory, therefore, the uncertain critical points were replaced by the corresponding points for which the density of the saturated vapour is 1 per cent. of that of the saturated liquid, these being determined for 20 substances, though of course with some uncertainty, by interpolation from the experimental results given by Young and his

co-workers. The reduced steam-lines were then plotted, but did not coincide, as the theory requires, except in particular instances; further, expressed in these new units, the critical temperatures varied from 1·36 to 1·44 and the critical pressures from 14·7 to 16·7, the alcohols being omitted from the list.

On plotting the values of $\log(p_c - p)$ in terms of $\log(T_c - T)$ for 30 substances, where p is the saturation-pressure at temperature T, curves were obtained which, except in the case of three alcohols, water and acetic acid, displayed surprising agreement when displaced parallel to the axes so as to be superposed over each other. Corresponding points could therefore at once be determined, and it was further found that the downward shift to produce coincidence of the curves was in each case $a + \log p_c$, where a is the same for them all. This result was verified by calculation, so that p_o in the above specification of π may be taken as 0, and corresponding pressures are consequently such as are the same fraction of the critical pressures.

The values of $\log(T_c - T) - \log(T'_c - T')$ for corresponding saturation-pressures were then calculated, where the dashes refer to C_6H_5F, and were found for any substance (except the above-named five) to be constant within the errors of experiment: these give the lateral shifts of the different curves for coincidence with that of C_6H_5F, and from them were deduced the values of T_o in the above specification of θ that correspond to $T'_o = 0$. The reduced saturation-pressure curve common to all the substances was then drawn with $1 - \pi$ as ordinates and $1 - \theta$ as abscissæ.

The values of $\log(v_c - v) - \log(v'_c - v')$ for corresponding saturation-pressures, where v denotes molecular volume in the saturated liquid state, were similarly examined and found to be constant for any substance except in the neighbourhood of the critical points, this being doubtless due to uncertainty of the experimental measures; from them the values of v_o in the above specification of ω corresponding to $v'_o = 0$ were deduced. Similarly were the values of $\log(V - v_c) - \log(V' - v'_c)$ examined, where V denotes molecular volume in the saturated vapour state: these were neither very constant for a given substance nor in good agreement with the similar differences found for liquids, as the theory requires: this is ascribed by the authoress to faultiness in the difficult experimental determinations of saturated vapour densities, which, while not proving the theory, are too uncertain to be taken as disproving it.

For the unsaturated vapours of isopentane, hexane, ether and CO_2 the theory is in good agreement with experiment, those constants being assumed which were found for the saturated state; among other things excellent correspondence is found for the reduced isometric variations of p with T.

The general conclusion is that the characteristic for a fluid is of the form—

$$f(p, v + \alpha, T + \beta, a, b, c) = 0,$$

where α, β, a, b, c are constants which differ with the fluid. The exception of the alcohols, &c., is due to the polymerisation of their molecules with fall of temperature. R. E. B.

1050. *Thermodynamics.* **M. Planck.** (Ann. d. Physik, 1. 3. pp. 621–624, March, 1900.)—The author defends against the objections raised by Wesendonck (see 1900, Abstract No. 74) his contention that every natural process leading to the reduction of the total entropy of all the bodies concerned in it can be utilised for the construction of a perpetual motion of the second type, *i.e.*, a periodically active machine converting heat into work without compensation. E. E. F.

[redacted]

SOUND.

1051. *Velocity of Sound.* **A. W. Witkowski.** (Acad. Sci. Cracovie, Bull. 16. pp. 138–157, 1899.)—Experiments made with compressed air by Kundt's method at various temperatures and pressures show that the velocity of sound varies with the pressure, the variation being greatest at the lowest temperatures. At zero the velocity slowly rises with the pressure, being about 10 per cent. higher at 100 atmospheres than at 1 atmosphere. At 100° the velocity remains nearly the same at all pressures, while at — 130° it rapidly falls with increasing pressure. E. E. F.

1052. *Effects of Sound.* **F. Larroque.** (Comptes Rendus, 130. pp. 359–360, Feb. 5, 1900.)—To measure comparative sound intensities the author uses an electromagnetic transmitter and receiver, the latter containing a core of iron filings. The sound is reduced to silence by suitably withdrawing a portion of the core, and the silencing points of two sounds are compared. The author studies the effects of sound and music upon the circulation. E. E. F.

1053. *Mechanism of Hearing.* **F. Larroque.** (Comptes Rendus, 130. pp. 119–120, Jan. 15, 1900.)—The author studies the action upon the ear of sounds produced by the bowing of a string stretched by a vessel containing water, which slowly flows away and thus releases the tension very gradually. He finds that when the sound is conveyed to the two ears through hearing-tubes, two distinct impressions are created, and there is no interference whatever by the phase of the two sound-waves. This shows that the auditory apparatus of any one ear acts independently of the other. The author discovered a peculiar break of continuity in his right ear, amounting to $\frac{3}{16}$ of a semitone between mi_3 and fa_3. He thinks that some of the Corti fibres have been accidentally broken, and looks forward to a future microscopic verification of his supposition. E. E. F.

1054. *Movements of Expired Air during Speech.* **E. Gellé.** (Comptes Rendus, 130. pp. 358–359, Feb. 5, 1900.)—Detailed study of the different vowels and consonants, and the corresponding currents and counter-currents of air. It is concluded that the intrabuccal column of air is not inert and that the buccal cavity does not act as a resonator as it is usually said to do. It is the air itself which, by its alternate condensations and dilatations which result from the action between the currents, produces the sub-vowels along with the laryngeal sound. A. D.

ELECTRICITY.

1055. *Electric Units.* **J. A. Fleming.** (Electrician, 44. pp. 324–326, Dec. 29, 1899; pp. 366–368, Jan. 5, and 402–404, Jan. 12, 1900.)—The author endeavours to formulate proposals for the revision of the electrical units so as to make them more clear and rational, and at the same time produce as little practical disturbance as possible in the way of altering existing instruments. He is generally guided by the principles of Heaviside, whose ideal system he approximates to as closely as possible. He points out that the power under which 4π enters as the multiplying factor to convert Heaviside reckoning into B.A. reckoning is in every case, except that of magnetic force and magnetic pole-strength, the same as the power under which the dimension of magnetic permeability makes its appearance in the dimensional expression. This remarkable fact supplies at once the clue to a modification of a suggestion made by Fessenden that the rationalisation of our present units can be effected by changing the unit in which we reckon magnetic permeability. If the magnetic permeability of ether is taken to be 4π units instead of unity, we rationalise at one stroke all our present units except the units of magnetic force and pole-strength. The author proposes the following modified system of units: "(i.) Let the permeability of the ether or air be considered to be 4π units absolutely, and not units as in the present system. (ii.) Let the unit magnetic pole be $1/4\pi$ times the present c.g.s. pole. This disturbs no one, because no practical electrician ever requires to measure a pole-strength in absolute measure. (iii.) Let the unit of magnetic force be the dekampere-turn per centimetre $=10$ ampere turns per centimetre $=4\pi$ times the present c.g.s. unit. (iv.) Let the unit of electric current be the present dekampere, and let it be called the ampere, or the new ampere. (v.) Let the unit of electric quantity be the present dekacoulomb, and be called the coulomb. (vi.) Let the unit of electric resistance be the present deciohm, or 0·1 ohm, and let it be called the ohm. (vii.) Let the unit of inductance be the present deci-henry, and let it be called the henry. (viii.) Let the unit of magnetic flux be the present c.g.s. unit or "one line of force" as at present used. (ix.) Let the unit of electromotive force be the present volt. (x.) Let the unit of magnetic potential difference or magnetomotive force be the present dekampere-turn or 10 present ampere turns. (xi.) The unit of power will then be 10 of the present watts and the unit of energy 10 of the present joules. (xii.) The unit of capacity will then be the present dekafarad (10 farads), and will be too large for practical use; but a fraction of it will have, as at present, to be employed, say one ten-millionth."

The above system of units is a rational system. In equations for expressing the relations of these units 4π appears only in its proper place, and the present practical system of electrical and magnetic measurement is not to any sensible extent disturbed.

The author further points out that probably all electric and magnetic phenomena can be simply described and discussed in terms of ten specific and integral quantities.

"Of the ten specific quantities, five are magnetic and five electric. The *gaussivity (magnetic* force), in consequence of the permeability or suscepti-

bility of the material or medium, produces in it flux or magnetisation. Magnetisation can only occur in ferromagnetic matter ; flux can occur in any substance, or even in free ether. The voltivity (electric force), in consequence of permittivity (specific inductive capacity) or conductivity of the material or medium, produces in it displacement or conduction. Conduction can only occur in certain materials (metals, electrolytes, &c.) ; displacement can occur in any substance, or even in free ether." E. E. F.

1056. *Electric Units.* **R. A. Fessenden.** (Elect. World and Engineer, 35. pp. 282–284, Feb. 24, 1900.)—The author discusses the desirability of a change in the existing units, and while considering those proposed by Fleming (see preceding Abstract) as very convenient and simple, would prefer to have absolute rather than "practical" units, and would distinguish electrostatic from electromagnetic units by the prefixes *sta* and *ma.* To go ahead with the present absolute and practical units would mean a loss of time of about three-quarters of a year for every electrical engineering graduate, and the perpetual annoyance of a complicated, irrational, and vexatious system of reckoning. (See also 1900, Abstract No. 643). E. E. F.

1057. *Transformations of Conducting Networks.* **J. Herzog** and **C. P. Feldmann.** (Elektrotechn. Ztschr. 21. pp. 167–171, March 1, 1900.)—The problem of current distribution in a conducting network when treated analytically leads to a system of linear equations. The solution may frequently be simplified by effecting various transformations which reduce the number of conductors in the network. The author considers the following transformations : (1) The replacement of a number of impedances joined in series by a single impedance ; (2) the replacement of a number of parallel impedances by a single impedance ; (3) the replacement by a single impedance of a system of two conductors which are bridged over by others at certain intervals ; (4) the replacement of a star by a $\triangle$, and *vice versâ.* Examples are given to illustrate the usefulness of these transformations.

A. H.

1058. *Application of Graphical Methods to Long Transmission Lines.* **F. Breisig.** (Elektrotechn. Ztschr. 21. pp. 87–92, Jan. 25, 1900.)—The author first explains an approximate graphical method of dealing with the problem of the transmission of an alternating current along a line possessing resistance, inductance, and capacity. The approximation consists in supposing the capacity concentrated at equidistant points of the line instead of uniformly distributed as is actually the case. Assuming that the potential and current at one of the points in the line to which a capacity is attached are known, we draw two vectors to represent these quantities in magnitude and phase. In proceeding along the line, the drop of potential along the section of the line between the starting-point and the next point to which a capacity is attached is given by the product of the current and impedance of that section. Subtracting this drop vectorially from the given potential vector, we get a new vector corresponding to the potential of the next point where a capacity is attached to the line. At this point a known condenser current (determined by the known capacity and the new value of the potential just found) leaves the line. On subtracting this vectorially from the given current vector, we obtain a new current vector which gives the current in the succeeding section of the line. By proceeding in this manner we obtain a number of potential and current vectors corresponding to various points along the line. The

author remarks that this method, besides not being strictly accurate, is laborious, and he next proceeds to consider the accurate graphical solution of the problem ; this, however, involves certain results of analysis. The loci of the extremities of the potential and current vectors are represented by spirals. In the concluding part of the paper the author describes a model by means of which the propagation of current along a line may be ingeniously exhibited. The model consists of a series of eccentrically mounted discs, the amount of eccentricity of any disc depending on the current amplitude at the corresponding point of the line, and the angle of advance of each elementary eccentric corresponding to the phase of the current. The discs are sufficiently numerous to present a practically continuous surface. Their shadow is projected on a screen, and when the discs are rotated the varying outline of their shadow shows the manner in which the current changes along the line both as regards amplitude and phase. The zero line is given by two concentrically mounted discs at the ends of the shaft carrying the discs.

A. H.

1059. *Energy of Electric Currents.* **A. Pérot.** (Écl. Électr. 22. pp. 5–18, Jan. 6, 1900), also **A. Potier** (Écl. Électr. 22. pp. 81–83, Jan. 20, 1900.)—In the first article Pérot aims at reducing to a minimum the number of experimental laws which must be regarded as indispensable to the establishment of the known laws of currents. Reversing the usual order of procedure, he starts from the laws of the induction of electromotive forces and hence deduces an expression for the potential energy of a current system. From this he deduces the laws of the production of magnetism by currents, and also the law of Biot and Savart relating to the mechanical force or conductors conveying a current in a magnetic field. The modifications caused by variable permeability and magnetic hysteresis are considered. The second article, by Potier, criticises Pérot's expression for the potential energy and gives reasons showing that it is not sufficiently general. W. E. S.

1060. *Diurnal Variation of Atmospheric Electricity.* **A. B. Chauveau.** (Journ. de Physique, 8. pp. 599–608, 1899.)—Although thirty different theories of atmospheric electricity have been proposed, the number of well-ascertained facts concerning it is exceedingly small. What the old physicists called the "soft electricity of fine weather" is now recognised as the most important factor in the phenomena. It is generally known that the earth's surface has a permanent negative charge, and the upper regions of the atmosphere a permanent positive charge, but the distribution of potential below an altitude of 1,000 m. is as yet very obscure. The author then describes the maxima and minima referred to in Abstract No. 70 (1899). Tropical stations, such as Batavia, hardly show the night minimum at all. The author, while pointing out the double oscillation, attributes the irregularities to the influence of the moisture of the soil. E. E. F.

1061. *Diurnal Variation of Atmospheric Electricity.* **A. B. Chauveau.** (Soc. Franç. Phys., Séances, 3. pp. 91–99, 1889.)—After discussing the maxima and minima referred to in Abstract No. 70 (1899), the author passes on to the analysis of two groups of observations, taken at Batavia. In the first group the collector was 2 m. above ground and near trees; in the second, 8 m. above ground and remote from trees and buildings. This second group shows the summer type. The material from polar regions is scanty. Eliminating the disturbed days from Lemström's observations in Finland

(lat. 68°) and from S. A. Andrée's at Cape Thordsen (Spitzbergen, lat. 78°), Chauveau arrives at mean annual diurnal variations of the winter type. In the first Batavia group, at the Collège de France (Mascart), and at Greenwich, the collectors are not well placed; the summer oscillation is simple, but differs from the winter type in so far that the maximum occurs at night-time, the minimum during the day. The author concludes that some disturbing influence of the earth which is strongest during summer (chiefly negatively charged water vapour, probably) complicates the diurnal variations of the electric potential which would otherwise be characterised by a simple oscillation with a high day value and a marked minimum between 3.30 and 4.30 a.m. Winter observations on the Eiffel Tower are highly desirable.

H. B.

1062. *New Powder Mixture for Lichtenberg Figures.* **K. Bürker.** (Ann. d. Physik, 1. 3. pp. 474–482, March, 1900.)—Instead of using a mixture of minium and sulphur, the author mixes 1 part by volume of carmine, 3 of lycopodium, and 5 of flowers of sulphur. The carmine and sulphur are first thoroughly mixed and the lycopodium is added last. The figures are reversed in colour with respect to the ordinary Lichtenberg figures, as the polarity of the sulphur is reversed in the combination. The figures obtained are of striking beauty. The circles have centres and outer halves of the opposite colour. E. E. F.

1063. *Wavy Spark Discharge.* **E. Ruhmer.** (Elektrotechn. Ztschr. 21. pp. 152–154, Feb. 22, 1900.)—There are two distinct forms of discharge which are obtained by using a Wehnelt interrupter and a spark-gap between a point and a disc. At large distances apart single strong sparks cross the gap, while at short distances a curved flame crosses from the point to the disc. The author describes a peculiar form of discharge which occurs at intermediate distances. It consists of a large number of thin spark lines branching out from the point and extending towards the disc like a brush. Every one of the lines has a sinusoidal wave shape, due in reality to a spiral form of the spark-path. When the sparks are successively photographed by a mutograph it is seen that they are very similar in outline, but that they are successively displaced with respect to each other in the direction of the disc. The author does not give a theory of the phenomenon, beyond discarding the suggestion of a magnetic influence and vaguely hinting at an attraction and repulsion of two simultaneous sparks owing to differences of phase. The displacement towards the disc is, however, explained by the "electric wind" blowing from the point, which displaces the spiral chains of temporarily conducting dust and air particles towards the disc. The displacement is at the rate of about 1 m. per second. E. E. F.

1064. *Wehnelt Interrupter.* **G. Pacher.** (N. Cimento, 10. pp. 444–447, 1899; Dagli Atti del R. Inst. Veneto, 58. 2. pp. 777–785, 1898–1899.)—The author describes various experiments made with a Wehnelt interrupter fed by a strong current. Tesla and Hertz phenomena are obtained in great intensity. An interesting experiment is described in connection with Vicentini's liquid coherer. A few drops of mercury are introduced into a narrow tube, and turpentine is added to fill it up. The mixture is heated until the mercury is broken up into minute drops. On placing the tube into the focal line of the receiving mirror, a single spark from the oscillator suffices to make the mercury coalesce into a few large drops. E. E. F.

1065. *Analysis of Condenser Discharges.* **F. Richarz** and **W. Ziegler.** (Ann. d. Physik, 1. 3. pp. 468–478, March, 1900.)—The authors noticed a peculiar appearance in the curves obtained on analysing a number of successive condenser discharges by means of a Braun kathode-ray tube and a revolving mirror. The appearance is that of an unsymmetrical herring-bone (see

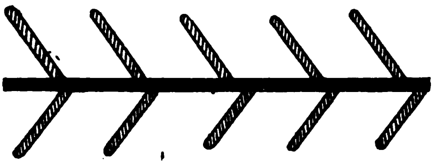

FIG. 1.

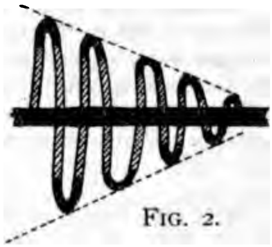

FIG. 2.

fig. 1), each discharge being represented by two ribs, an upper and a lower one. The introduction of a high inductance proved that this is due to the superior intensity of the turning-points (see fig. 2), which coalesce into two convergent luminous lines. The centre line is the track of the fluorescent spot on the screen. E. E. F.

1066. *Constitution of the Electric Spark.* **A. Schuster** and **G. Hemsalech.** (Roy. Soc., Phil. Trans. 193. pp. 189–213, 1899.)—Some of the results of this investigation were announced in Abstract No. 1377 (1899). The present fuller account contains very interesting descriptions of the methods and apparatus used for photographing sparks and spark spectra on a rapidly moving film, and of the manner in which the results are interpreted; reproductions of the photographs are also given. The authors do not claim great accuracy for their estimates of molecular velocities, but are able to state generally that metals of light atomic weight, like aluminium and magnesium, are projected from the poles with greater velocities than heavier ones, such as zinc, cadmium, and mercury. The results for bismuth are not easily explained, except by assuming the presence of different kinds of molecules having different masses, the lighter ones diffusing more quickly. The method used is likely to prove of extreme value in separating the effects of different molecules.

When two lines of a metal are of unequal intensity it is not always due to the fact that at any period of the discharge the vibrations which appear the strongest are really the most intense. Our eye or the photographic film only perceives the total energy sent out, and the time of luminosity is in many cases very different for different lines. A vibration which is weak, but persists, may appear stronger than one of greater intensity which only appears for a very short time.

When a coil of wire of sufficient self-induction is introduced into the spark-circuit, the air-lines completely disappear. The explanation appears to be that the air-lines are produced entirely by the first initial discharge, when the spark-gap contains no metallic vapour. The subsequent oscillations, on the contrary, pass through the metal vapour, which meanwhile has had time to diffuse away from the electrodes. By inserting the coil, the initi discharge takes place more slowly and apparently does not heat up the ai sufficiently to yield the line spectrum. The duration of the spark is cor lerably lengthened, and the discharge may pass through the metal vapor

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which after a few millionths of a second fills the whole spark-gap. This method of removing the air-lines may prove very useful, as they are often troublesome in the investigation of spark-spectra.

Finally, the appearance of calcium lines in the photograph of the spectrum of fairly pure silver has shown the existence of a new type of spectroscopic lines, namely, one that starts in the centre of the spark and is propagated towards the poles. D. E. J.

1067. *Electric Discharge.* **P. Villard.** (Comptes Rendus, 130. pp. 125–127, Jan. 15, 1900.)—A flame placed in an electric field acts as a bundle of Röntgen rays would do, cutting the lines of force, and the gases produced by the combustion are active like Röntgenised air. In the absence of an electric field the flame is inactive and the gaseous products, transported into an electric field, produce no discharge. It is as if in ordinary air the incandescent particles gave out kathode rays, while in a field they gave out Röntgen rays; or rather analogues to these. This would explain flame discharges, discharges by incandescent bodies and phosphorus, the peculiar radiations given out by electric sparks, especially from the kathode end of the spark, discharge by ultra-violet light, the Edison effect (current between the positive end of the filament of a glow-lamp and an electrode fused into the lamp), the production of ozone by flames, incandescent bodies, the electric arc and sparks, and by the oxidation of phosphorus in the cold, and the production of ozone by radium. A. D.

1068. *Electric Discharge in Large Quantity.* **J. Trowbridge.** (Elect. Rev. N.Y. 36. p. 5, Jan. 3, 1900.)—This short note accompanies two photographs of electric discharges of very large quantities. One hundred and fifty plate-glass condensers, 18″ × 20″ × $\frac{1}{8}$″ thick are arranged in multiple and charged to 20,000 volts by means of 10,000 Planté cells. One photograph represents the deflagration of 6 inches of No. 30 iron wire and the other the deflagration of a similar piece of wire arranged as a shunt to a spark-gap. A spark occurs at the spark-gap simultaneously with the deflagration of the wire.

The author therefore concludes that a spark might occur inside a metallic cage when large quantities are in question. A cage would not, therefore, in all cases completely protect a powder magazine against lightning.

J. B. H.

1069. *Striated Electrical Discharge.* **J. H. Jeans.** (Phil. Mag. 49. pp. 245–262, March, 1900.)—This paper, which forms an important contribution to ionic theory, is a sequel to one by Professor J. J. Thomson on the "Theory of Conduction of Electricity through Gases by Charged Ions" (see 1899, Abstract No. 1156). The solution obtained by Thomson for the discharge in rarefied gases between electrodes does not account for the striations; the present paper contains a mathematical investigation of Thomson's equations and conditions to see whether a periodic solution does not exist, which will satisfy the conditions of the luminous striated discharge.

The equations do not lend themselves to definite solution, and in the paper they are treated graphically, the different families of curves which satisfy them being drawn. The various physical conditions at the electrodes and throughout the tube are satisfied by one set of these curves which are of a periodic nature and, under certain assumptions which the author justifies, they satisfy all the known conditions of striated discharge. J. B. H.

1070. *Minimum Sparking Potential for Various Gases.* **R. J. Strutt.** (Roy. Soc., Phil. Trans. 198. pp. 377–394, Jan. 9, 1900.)—This paper deals with experiments undertaken to test the sparking potential in various gases at various pressures, between large parallel planes at a fixed distance apart. It was previously found by Peace that the sparking potential between two parallel plates in air diminished as the pressure diminished till a certain point is reached, and then began to rise rapidly. The pressure at which the sparking potential was a minimum depended on the distance between the plates, and increased as this distance was lessened. The minimum potential itself, however, varied very little with the distance between the plates. This minimum potential, as pointed by J. J. Thomson, was of the same order as the kathode fall of potential. In the experiments here described a Wimshurst machine was used as the generator of the required potential difference. Its terminals were connected to those of a fluid high-resistance column of variable length. This admitted of easy adjustment of the potential to the required nicety. To insure electrical steadiness a Leyden jar was also connected across the terminals of the machine. In series with the jar and the spark-gap was placed a telephone. The telephone indicated by a click the passage of a spark, the voltmeter being simultaneously read. A gas is found able to sustain for a short time a potential difference about three times as great as that required to produce discharge through it when this initial resistance has been broken down. This second lower value was always recorded as it was desired to compare the minimum potential with measurements of the kathode fall, in which a continuous current was passing through the gas. The paper gives curves and tables for several gases and describes the elaborate precautions taken to insure their purity. The following are values of the minimum potentials found: Air, 341 volts; hydrogen, 302 to 308 volts; nitrogen, 251 volts; helium, 261 volts. The experiments are held to establish the equality of the minimum spark potential and the kathode fall. E. H. B.

1071. *Potential Gradient in Rarefied Gases.* **G. C. Schmidt.** (Deutsch. Phys. Gesell., Verh. 1. 15. pp. 265–268, 1899.)—Measurements were made of the potential gradient in the positive light and near the kathode, of the potential gradient in dark discharges, and the variation of the total potential difference with the temperature. The current was furnished by a battery of 1,000 accumulators, and platinum probes were inserted into the vacuum tube at short distances. It was found that as the temperature rises the positive light becomes stratified, the stratifications becoming brighter and less defined as the current strength is increased. At the same time the positive light withdraws towards the anode, so that eventually the discharge becomes altogether dark. On introducing a spark-gap in the circuit, the tube lights up again, thus showing that the gas has not lost its power of luminosity, but that the discharge has assumed another form. The glow-light also experiences striking changes. When the kathode is heated, the glow-light extends, and the more so the smaller the pressure. The potential gradient in the unstratified positive light is independent of the temperature, and so is the gradient near the kathode. In the dark discharge the gradient increases with increasing current strength, and also with increasing temperature, if the density of the gas remains constant. But if the pressure remains constant, it decreases with the temperature. With increasing temperature, the total potential difference decreases at first slowly, and then more rapidly, attains a minimum, and then rises again. E. E. F.

1072. *Are Rarefied Gases Electrolytes?* **E. Bouty.** (Journ. de Physique, 9. pp. 10–17, Jan., 1900.)—J. J. Thomson's researches indicate that gases under a pressure of 0·005 mm. may behave as electrolytes. But all known electrolytes obey Faraday's law and yield at the electrodes products of decomposition proportional in quantity to the quantity of electricity passing between the electrodes. Now E. Wiedemann has studied from this point of view gaseous hydrochloric acid, and the vapours of the chloride, bromide, and iodide of mercury. He only found, especially with the last three, insignificant quantities of products of decomposition, amounting to 3 or 4 per cent. of what would be required by Faraday's law. Furthermore, the products of decomposition presented themselves almost indifferently at both electrodes. Their presence can be sufficiently explained by secondary reactions (*e.g.*, thermal actions) and Wiedemann concludes that a rarefied gas cannot be regarded as a true electrolyte. From his own experiments (see 1899, Abstract No. 1898) the author comes to a similar conclusion. He finds that the apparent conductivity of a rarefied gas is essentially connected with its luminescence: the gas luminesces wherever it permits electricity to pass. The apparent conductivity is directly connected with a phenomenon of a brusque and violent nature which follows the phenomena of dielectric equilibrium abruptly, as the rupture of a stretched wire follows its elastic equilibrium when the stretching force exceeds a certain limit. The ether in a perfect vacuum possesses perfect dielectric elasticity: we cannot break down its dielectric cohesion. But gaseous molecules introduce weak points into it, and when they are present the dielectric cohesion becomes measurable. D. E. J.

1073. *Potential Gradient in Gaseous Mixtures.* **W. Heuse.** (Deutsch. Phys. Gesell., Verh. 1. 15. pp. 269–271, 1899.)—Minute quantities of mercury vapour in hydrogen are easily discovered by means of spectrum analysis, but it is very difficult to discover traces of hydrogen in mercury vapour by the same means. Similarly, small traces of hydrogen or nitrogen are easily discovered in helium, but not the reverse. These facts lead to the question as to how the constituents of a gaseous mixture are concerned in the conduction of a current. The author has therefore studied the potential gradient in the unstratified positive glow-light in (1) nitrogen, (2) mercury vapour, (3) a mixture of both. In nitrogen, the potential gradient maintains the same value of about 37 at all temperatures between 20° and 200°. In mercury vapour, the gradient slowly rises with the temperature, but not in proportion to the pressure of the vapour. In a mixture of nitrogen and mercury which is heated up from 18° to 200°, the potential gradient falls at first, reaches a minimum of 27·3 volts at 91°, and after that it increases at the higher temperatures to a value some 10 volts greater than that due to the two constituents taken singly. E. E. F.

1074. *Repulsion of Vacuum-Tube Electrodes.* **F. Neesen.** (Deutsch. Phys. Gesell., Verh. 1. 14. p. 253, 1899.)—This is a reply to Ebert's criticism of the author's explanation. (See 1900, Abstract No. 115.) The attraction produced by the ascent of a hot stream of gas between the plates does not enter into consideration in the case of a vacuum tube, as the pressure on the outside of the plates would be negligible. As regards the second objection to the author's explanation, the author does not acknowledge that heating necessarily alters the fall of potential between the electrodes. He adheres

1075. *Velocity of Kathode Rays and Electrolytic Conductivity of Gases.* **A. Battelli** and **A. Stefanini.** (N. Cimento, 10. pp. 324–337, 1899.)—The velocity of kathode rays is in any event far less than that of light; and it varies with the rarefaction of the gas. There is some reason for believing that the phenomenon is the summation of molecular displacements and etheral phenomena, either undulatory or translatory, along with chemical changes resulting in the production of ions whose velocities depend on the rarefaction of the gas and on the potentials at the electrodes. There appear to be no free ions in rarefied gas under normal conditions; but ionisation is caused by the presence of a sufficient difference of potential. A. D.

1076. *Energy Expended in Oscillating Discharges in Vacuum Tubes.* **G. Telesca.** (N. Cimento, 10. pp. 420–431, 1899.)—The ratio between the quantity of heat developed in the ordinary spark and that developed in the vacuum tube, other conditions being the same, increases with the rarefaction, with the explosive distance, with the period of oscillation and with the damping. The ratio between the amount of heat developed in the tube and that in the metallic circuit decreases as the same data increase. The ratio between the heat in the spark and that in the metallic circuit diminishes with increase in the rarefaction, in the capacity, in the damping, and in the period of oscillation, but increases with the explosive distance and with the self-induction. A. D.

1077. *Velocity of Electric Waves in Air and along Wires.* **C. Gutton.** (Soc. Int. Élect., Bull. 16. pp. 311–315, 1899.)—A linear Hertz oscillator is placed in the focal line of a parabolic mirror facing a similar mirror provided with a resonator. From the latter, two parallel wires proceed to a Branly coherer which is also connected to the oscillator by another pair of wires: the latter are longer than the first pair and their length can be varied. The distance between the focal lines of the mirror is 5·4 metres. The wires from the oscillator are crossed and their length is adjusted so that no effect is produced on the Branly tube. The mirrors are now brought 4 metres nearer each other, and the velocities in air and along the wire are compared by finding what length has to be added to the pair of wires proceeding from the resonator to the tube in order to compensate for the shortening of the distance traversed in air. It is found that no effect is produced on the Branly tube when the increase of length is 4 metres. Thus the velocities in air and along wires are equal.

The method can be used for comparing the velocity in air with that in a given dielectric by introducing a plate of the latter between the mirrors. (See also 1899, Abstract No. 1498.) D. E. J.

1078. *Hertz Wave-Receiver.* **F. J. Jervis-Smith.** (Nature, 60. p. 486, 1899.)—In the suspended system of a d'Arsonval galvanometer of 500 ohms resistance, a small projecting Branly receiver is introduced. The galvanometer is connected in series with a resistance of 16,000 ohms and a single dry cell. On receipt of electric waves the Branly receiver becomes conducting and the galvanometer deflection indicates the fact. At the same time decoherence is automatically caused by a projecting knob on the centre of an elastic disc kept vibrating by a jet of water. The coherer is brought up against this knob at each deflection so that coherence is immediately followed by decoherence. The author found that less than $\frac{1}{16}$ of a milliampere sufficient to give a deflection. E. H. B

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1079. *Flames Containing Salt Vapours.* **H. A. Wilson.** (Roy. Soc., Phil. Trans. 192. pp. 499–528, 1899. See also 1899, Abstract No. 1722.)—Conductivity of flames is similar to that of Röntgenised gas (Roy. Soc., Proc. 64. p. 142). The saturation value of the current as the E.M.F. is increased depends on the temperatures of the electrodes, and not on the motion of the flame-gases. The current is always greater when the hotter electrode is negative than when it is positive. When both electrodes are at a bright red heat, the upper electrode being positive, the fall of potential is very similar to that observed in gases at low pressures; a rapid fall of potential near each electrode and an approximately uniform small potential gradient in the intervening space. When the upper electrode is negative, nearly all the fall of potential occurs near this electrode. When the two electrodes are both kept hot, the saturation current is independent of the distance between the electrodes, whereas if the salt vapour were ionised throughout the flame the current should have increased with the distance between the electrodes. There is a small amount of such ionisation throughout the flame, but this is only a small fraction of that observed when the electrodes are both hot enough to glow: and unless the salt vapour actually comes in contact with the glowing electrodes, the conductivity of the flame is not affected by its presence. The ionisation of the salt vapour occurs almost wholly at the surfaces of the glowing electrodes. When a hot air stream was substituted for the flame, the current was zero up to about 25 volts for 1 cm. distance, after which it increased uniformly with the P.D. The necessary P.D. increased more rapidly than the distance, except when this was less than about 1·5 cm.: and for small variations the necessary P.D. varied directly as the velocity of the air-blast. Increasing the temperature increased the amount of current obtained, and diminished slightly the least necessary P.D., and also diminished the least distance at which satisfactory results could be obtained. The velocities of negative ions were 26 cm./sec. for 1 volt/cm., of positive ions of salts of Li, Na, K, Rb, and Cs 7·2, and of positive ions of salts of Ba, Sr, and Ca 3·8. The velocities in hot air are much smaller than those in the flame, about one-fortieth, the respective temperatures being about 1,000° and 2,000°. The velocity of negative ions in the flame, 1,000 cm./sec., is of the same order of magnitude as the theoretical velocity of an ion consisting of one atom. That other velocities are less than this shows that the ions consist of clusters of atoms (assuming that they carry the same charge as the ions in electrolysis of solutions), which clusters are larger in positively than in negatively charged ions. The size of the cluster of atoms forming a gaseous ion depends, at a given temperature, only on the charge on the ion. Those ions which have equal charges also have equal velocities in the same medium. Under the slope of potential at the surface of the electrodes the negative ions, having higher velocities, are more easily dragged away than the positive ions; so that unless the slope of potential is great enough, a given slope of potential at the electrode will cause a greater current when the electrode is negatively than when it is positively charged. If one electrode be hot, the other cool, there will be only one kind of ion between the electrodes: this will diminish the potential slope near the hot electrode, and *vice versâ.* If both be hot, the positive ions travelling more slowly accumulate in the gas and affect the fall of potential, which becomes more rapid at the negative than at the positive electrode, with the consequence that the more mobile negative ions may mainly carry on the current, but the current carried by the positive ions continues to increase nearly uniformly with the E.M.F. If the positive

electrode; the negative ions are dragged out, and so far as the negative ions are concerned the current attains its saturation value; but the current will be much smaller than when the negative electrode is hot. There is a very close analogy between the conductivity of salt vapours in flames and the conductivity of gases at low pressures. In both cases there is a greater fall of potential near the negative than near the positive electrode, with a small slope of potential in the intermediate space; and probably the peculiar form of the fall of potential in gases at low pressures is due, like that in the flame, to a great difference between the velocities of the positive and negative ions. A. D.

1080. *Deformation of Polarised Dielectrics.* **P. Duhem.** (Journ. de Physique, 9. pp. 28–30, Jan., 1900.)—In 1892 the author showed how the principle of virtual velocities should be applied to polarised dielectrics or magnetic media. The method used appears to be valid, but unfortunately an error slipped into the calculations: in estimating the virtual variation of the dielectric or magnetic potential a quantity was neglected as being infinitely small and of the second order, whereas it was really of the first order. On account of this error the conditions of equilibrium given for different points of the limiting surface of a polarised medium were incorrect, but the conditions within the interior of the magnetic or dielectric mass were correct. The error was pointed out by Liénard, who evaluated the neglected term and gave a correct theory of the pressure within polarised media. This theory shows one remarkable peculiarity. In order to maintain a polarised fluid in equilibrium it is necessary to apply to each element of its limiting surface a pressure whose direction is normal to the element, but whose magnitude depends on the orientation of the element. The magnitude at any point is $2\pi\epsilon M^2 \cos^2 (M, N)$, ϵ being the constant of Coulomb's laws and M the intensity of polarisation. When the body is polarised so feebly that we can neglect its potential on itself this pressure introduced by Liénard becomes proportional to the square of the intensity of the field and *to the square of the coefficient of polarisation of the body.* All the other terms for the pressures produced by polarisation are proportional to the square of the intensity of the field and *to the first power of the coefficient of polarisation.* The terms introduced by Liénard may therefore be neglected in the case of feebly dielectric or magnetic bodies: for such bodies the theory given by Duhem holds good. On the other hand the complementary term becomes very important in the case of strongly magnetic bodies, such as soft iron. D. E. J.

1081. *Comparing Self-inductances.* **H. V. Carpenter.** (Phys. Rev. 10. pp. 52–62, Jan., 1900.)—The two coils whose self-inductances are to be compared are connected in parallel, and in series with one of them is a non-inductive resistance. Apply to their common terminals a harmonic potential difference. The currents in the two coils will be in phase if the time constants of the two branches thus formed are the same. This can be attained by varying the non-inductive resistance, which is obviously put in series with the coil of greater time constant. The ratio between the self-inductances of the coils will be equal to the ratio between the resistance of the two branches when the currents are in phase.

The paper describes two methods of determining when the currents in the two branches are in phase, one method by means of a telephone in serie with two coils which act as secondaries to the coils to be compared, the

secondary coils being connected so that their induced E.M.F.'s are in opposition. In the second method the telephone is replaced by a modification of the Siemens dynamometer. E. C. R.

1082. *Measurements on the Microphone.* **J. Cauro.** (Soc. Franc. Phys., Séances, 3 pp. 112–115, 1899.)—When a sound wave strikes the microphone the current i becomes $i' = i(1 + \alpha + \beta)$, where α is a continuous variation and β is an alternating variation having the same period as the sound. The effective fraction of the alternating variation of the primary current is independent of that current and is less than $\frac{1}{4}$. M. O'G.

1083. *Influence of the Dielectric upon Resistance.* **E. Drago.** (N. Cimento, 10. pp. 447–450, 1899; Atti Acc. Gioenia di Catania, vol. 12, ser. 4.)—German-silver wire was tested for the alleged influence of the dielectric upon the resistance described by Sanford in 1892 (see Phys. Soc. Abstracts, No. 34, 1896). The dielectric used was petroleum. No such effect as alleged was observed, and the author concludes that it does not exist, or is too small to be detected. E. E. F.

1084. *Specific Resistance of Nickel.* **J. A. Fleming.** (Roy. Soc., Proc. 66. pp. 50–58, March 8, 1900.)—Mathiessen's determinations of the specific resistances of various metals made in 1860 to 1865 are usually shown to be correct within very narrow limits by more recent experiments. For nickel his value of 12,320 c.g.s. units at 0° C. is usually assumed. Recently the author has made a special investigation of the specific resistance at temperatures ranging from $-182°$ to $+95°$ C. of a nickel wire 250 cm. long and 0·02567 cm. in diameter prepared electrolytically from a purified solution of nickelous chloride and annealed in hydrogen. The results are tabulated and plotted as a curve which tends as usual to pass through zero at the absolute zero of temperature. The specific resistance thus determined is only 6,935 c.g.s. units at 0° C., and the mean temperature variation is 0·00618. between 0° C. and 100° C. The discrepancy is probably due to some impurity in Mathiessen's specimens. L. B.

1085. *Electrical Resistance between Opposite Edges of a Symmetrical Quadrilateral Sheet.* **C. H. Lees.** (Manchester Lit. and Phil. Soc., Mem. 44. 1. pp. 1–3, 1899–1900.)—By means of a transformation theorem given by Maxwell the author transforms the stream and equipotential lines of the quadrilateral sheet in question to those of an equivalent square, whence the resistance required immediately follows. E. H. B.

1086. *Polarisation and Resistance of the Copper Voltameter.* **B. E. Moore.** (Phys. Rev. 10. pp. 34–51, Jan., 1900.)—The author describes various experiments with the copper voltameter, showing the change of polarisation with time, using both closed and open circuits. Measurements of the polarisation are given for times varying from 0·00006 to 0·045 second after the removal of the polarising E.M.F., the copper sulphate solution being kept at a constant density (1·1395). The results of the experiments, which are given graphically, indicate that the current first produces a change at the surfaces of contact of the solution and the electrodes, the amount of this change increasing, and thicker layers of the solution being affected as time goes on. The diffusion which takes place in the liquid opposes the increase of polarisation, and finally causes it to vanish. When the current is small and the layer of

affected by the concentration changes is consequently small in width, the polarisation decreases very rapidly; for stronger currents, with which the changes in concentration of the solution spread farther from the electrodes the polarisation diminishes less in a small interval, and the values obtained for the true resistance correspond more nearly with the values obtained when alternating currents are employed. T. H. P.

1087. *Electrolytic Interrupter for Feeble Currents.* **A. v. Rzewuski.** (Ann. d. Physik, 1. 3. pp. 614–616, March, 1900.)—If it is the oxygen accumulating at the anode which prevents the electrolytic interrupter from working with weak currents, any process which counteracts that accumulation must lower the minimum of E.M.F. required. A violent motion of the active electrode effects this. But better results are obtained by directing a current or jet of dilute acid against the electrode, the necessary pressure being obtained by raising the reservoir about a yard above the interrupter. With such an arrangement 24 volts suffice to obtain a uniformly interrupted current of great steadiness. When the pressure of the acid is too high the current becomes continuous. An incidental advantage is that the current of acid keeps the apparatus cool. E. E. F.

1088. *Durable Wehnelt Interrupter.* **R. H. Cunningham.** (Elect. Rev. N.Y. p. 7, Jan. 3, 1900.)—The brass rod bearing the platinum anode is encased in hard rubber tipped with a lava bushing. The kathode consists of a coil of lead tubing through which cold water is circulated. E. E. F.

1089. *Comparison of Different Forms of Wehnelt Interrupter.* **A. Turpain.** (Comptes Rendus, 130. pp. 409–412, Feb. 12, 1900.)—Foucault's interrupter and various forms of Wehnelt interrupter are considered. The Wehnelt form with a long wire of platinum renders the interruptions irregular, and the interrupter is not durable. The modifications of the Wehnelt interrupter described by Caldwell and Simon are next mentioned (See Elec. Rev. N.Y. 34. p. 311, 1899; and S. A. 1899, Abstracts Nos. 1918 and 1919). By arranging three vessels of unequal size one inside the other, pierced with holes, excepting the exterior vessel, and containing each an electrode formed of a sheet of lead, an interrupter is obtained which can work with variable potential differences. The experimental facts observed show clearly that electrolysis plays no part in the working of the interrupter with platinum wire, or of that with holes pierced through a test tube.

The author concludes that from the point of view of *durability* and *economy* the Wehnelt interrupter with orifices (like that described by Simon, see 1899, Abstract No. 1919) is to be preferred to that with platinum wire. Both are preferable to that of Foucault, both from the above point of view, and from those of *convenience* and *rapidity*. As to *regularity* and *power* within the limits of speed between which it works, the interrupter of Foucault does not yield to that of Wehnelt. It allows, moreover, of the variation at will of the number of interruptions per second. J. J. S.

1090. *Inversion of the Hepta- and Hexa-hydrates of Zinc Sulphate in the Clark Cell.* **H. T. Barnes.** (Journ. Phys. Chem. 4. pp. 1–20, Jan., 1900.)—The conversion of $ZnSO_4.7H_2O$ into $ZnSO_4.6H_2O + H_2O$, which takes place at 39°, leads to a break in the curve representing the variation of the E.M.F. of a Clark cell with temperature (Callendar and Barnes, Proc. Roy. Soc. 62. 150 97). *Using the* B.O.T. "Crystal" cell, it was found that the hexahydrat

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crystals did not persist in a metastable condition below 30°, whereas in the old form of cell with an excess of solution and few crystals the hexahydrate could be preserved as low as 0°, leading of course to abnormal values for the E.M.F. of a cell which had been heated above 40°; the reverse change of the heptahydrate to hexahydrate occurred at about 42°. The heptahydrate branch of the curve, which has been traced up to 42°, is represented for a mean temperature of 39° by the formula—

$$E_t - E_{39} = -1\cdot635\,(t-39) - 0\cdot0140\,(t-39)^2,$$

whilst the hexahydrate branch, which has been traced down to 30°, is represented by—

$$E_t - E_{39} = -1\cdot000\,(t-39) - 0\cdot007\,(t-39)^2;$$

the exact point of intersection of the two E.M.F. curves is 38·78°. The transition point of zinc sulphate, as determined from the intersection of the solubility curves of the two hydrates is nearly a degree higher, viz., 39·95°; the difference is probably due to the lowering of the transition-point of the zinc sulphate by the mercurous sulphate present in the Clark cell.

Above 35° the Clark cell appears to undergo a secondary change, causing the E.M.F. to fall off more rapidly than at lower temperatures. In preparing the zinc sulphate for the "Crystal" cell, it has been noticed that if the saturated solution be treated with mercurous sulphate above 35° a yellow turbidity appears on cooling, which does not appear if the temperature does not rise above 30°; this observation is probably associated with the more rapid falling off in the E.M.F. of the cell at these temperatures.

[*Cf.* Jaeger, Wied. Ann. 63. p. 354, 1897; Abstract No. 811 (1898).]

T. M. L.

1091. *E.M.F. of Clark and Weston Cells.* **W. Marek.** (Ann. d. Physik, 1. 3. pp. 617–620, March, 1900.)—This is a set of tables of the E.M.F. of Clark cells at temperatures ranging from 0° to 30°, and of Weston cells between 0° and 10° calculated from the formulæ supplied by the researches of the Physikalisch-Technische Reichsanstalt. E. E. F.

1092. *Voltaic Cells with Compound Electrodes.* **F. S. Spiers.** (Elect. Rev. 45. pp. 911–912, Dec. 8, and p. 953, Dec. 15, 1899.)—If a cell has one plate of brass and the other of zinc with a plate of steel in contact with the latter beneath the electrolyte, the E.M.F. varies with the position of the zinc and steel plates relatively to the brass. For example, when the steel faces the brass the E.M.F. is 0·6 volt, but when the zinc faces the brass the E.M.F. is 0·9. The same effect is seen when a copper-plated iron rod, from which some of the copper is removed, is opposed to a copper plate. When only a very small piece of the iron is exposed the E.M.F. is the same whether the spot of iron is facing the copper plate or is turned away from it; but if a considerable length of the rod on one side is exposed, the E.M.F. differs in these two positions. The author attributes this phenomenon to the presence of local currents between the two parts of the compound electrode. The work done on a unit of electricity in moving it from one pole to the other depends upon the E.M.F. of the couple increased or diminished by drop of potential along the stream line of local current which is chosen as the path, and the E.M.F. therefore depends upon the relative positions of the plates. The explanation is confirmed by measurements of P.D. between the compound electrode and various points on a stream line. The author finally discusses the protective action of zinc in boilers. W. R. C.

1093. *Alternating Current Diagrams.* **R. A. Philip.** (Elect. World and Engineer, 34. pp. 970–972, Dec. 23, 1899.)—The actual circuit is represented by a conventional diagram called the circuit diagram, which differs from the usual conventional picture of the circuit in that the latter shows the mechanical relations of the parts of the circuit to each other and to other related objects, while the former is concerned with the electrical connections only. The essential features of this diagram are that it shall show every junction-point and every branch.

Difference of potential has only two qualities, amplitude and phase, and these may be represented by a length and an angular direction respectively. In order that this representation may be definite in a given diagram, it is necessary to assume some length as a unit of potential measurement, and some direction as a basis of phase angle displacement. Absolute potential is the difference of potential between a given point and the zero point. Therefore, when any one point of a diagram is assumed to represent a given absolute potential, each other point will also represent a definite absolute potential.

In constructing a potential diagram for a circuit from the circuit diagram

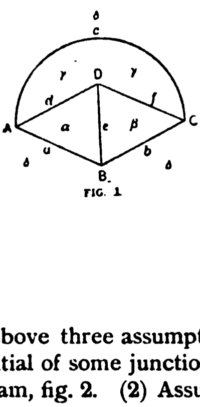

FIG. 1

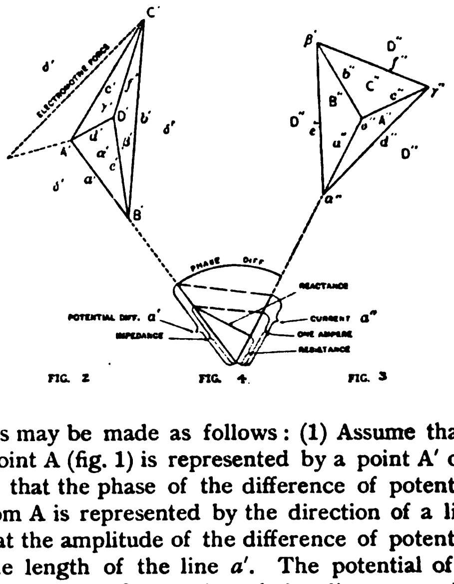

FIG. 2 FIG. 4. FIG. 3

the above three assumptions may be made as follows: (1) Assume that the potential of some junction point A (fig. 1) is represented by a point A′ of the diagram, fig. 2. (2) Assume that the phase of the difference of potential in some branch *a* radiating from A is represented by the direction of a line *a*′ through A′. (3) Assume that the amplitude of the difference of potential in the branch *a* is equal to the length of the line *a*′. The potential of each junction point now corresponds to a definite point of the diagram, and it is only necessary to mark these points in order to represent the junction point potentials; these points may be styled junction points of the potential diagram.

Comparing the potential diagram with the circuit diagram: (1) Junction points correspond to junction points. (2) Connecting lines correspond to branches. (3) Meshes correspond to meshes.

In constructing a current diagram three assumptions may be made as follows: (1) Assume that some mesh (say *a*′ fig. 2) of the potential diagram corresponds to some point *a*′ of the current diagram, fig. 3. (2) Assume th the phase of the current in some branch bounding the mesh *a*′ (say *a*′) *represented* by the direction of the line *a*″ through the point *a*″. (3) Assu

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that the current amplitude in the branch a' is equal to the length of the line a''.

Each mesh of the potential diagram now corresponds to a definite point of the current diagram, and it is now necessary to find these points. From the point a'' construct all the currents which bound the mesh a'. The point at the outer extremity of each of these current vectors represents the mesh of the potential diagram which the corresponding branch separates from the mesh a', and so on.

Comparing the current diagram with the potential diagram: (1) Junction points correspond to meshes. (2) Currents correspond to connecting lines. (3) Meshes correspond to junction points.

Fig. 4 shows the construction for the determination of the impedance and resistance of the circuits. W. G. R.

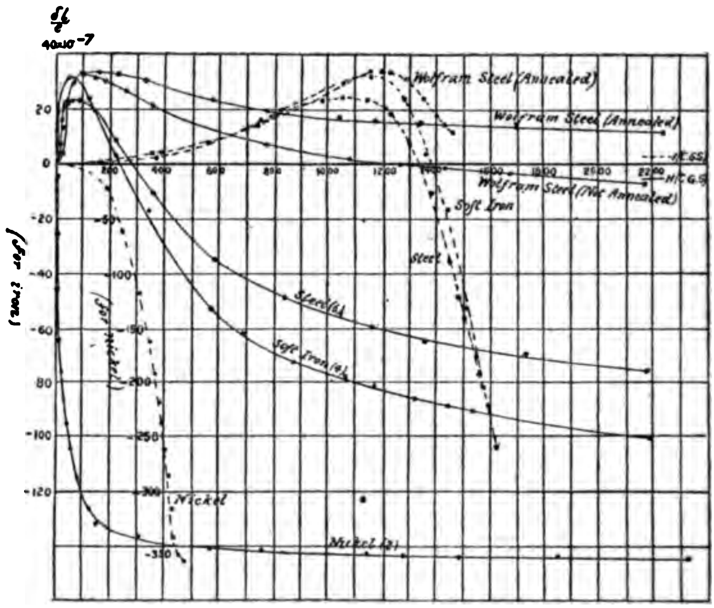
1094. *Optical Methods of Determining Wave-Forms.* **E. E. Seefehlner.** (Zeitschr. Elektrotechn., Wien, 18. pp. 5–8, Jan. 1; 23–25, Jan. 7; 44–46, Jan. 21; and 55–59, Jan. 28, 1900.)—This is an account of a large number of experiments carried out by the author with a Braun tube (see Phys. Soc., Abstract No. 277, 1897). Two methods were used for obtaining the wave-shape: (1) Photographing the wave on a cylinder covered with sensitised paper and driven by a small synchronous motor; (2) Using an auxiliary alternating deflecting field at right angles to that produced by the current under investigation, and making the phase difference between the two fields equal to ¼ period; if the law of variation of the auxiliary field is known, the wave-form of the current under examination may obviously be deduced from the closed curve traced out on the phosphorescent screen of the Braun tube under the combined action of the two fields. The author points out that a Braun tube is extremely well adapted for the rapid measurement of the amplitude factor $\left(\frac{\text{R.M.S. value}}{\text{maximum value}}\right)$. All that is necessary for this purpose is a measurement of the deflections of the phosphorescent patch caused by the alternating current, and by a continuous current equal to the R.M.S. value of the alternating current. A. H.

1095. *Application of Braun Tube to Study of Hysteresis.* **K. Ångström.** (Elect. Rev. N.Y. 36. p. 38, Jan. 10; Phys. Rev. 10. pp. 74–82, Feb., 1900. Paper read before the Konglish Vetenskaps-Akademiens Forhandlingar.)—Four coils, spaced 90° apart, are connected in series and are arranged with their axes in a plane close to the diaphragm of a Braun tube. One pair of coils, whose axes are along a vertical diameter of the tube, contains no iron cores, so that their deflecting effect on the kathode rays is proportional to the current, and hence to the magnetic force. The horizontal pair of coils, on the other hand, contains samples of the material to be tested. The deflecting effect of this second pair of coils is proportional to the magnetisation of their cores. If the two sets of coils are connected to a source of alternating E.M.F., a fluorescent hysteresis loop appears on the screen of the Braun tube. Specimens of loops obtained in this manner are given. The following modification is suggested by the author for comparing different samples. Each of the two horizontal coils contains a different sample (instead of identical ones as in obtaining the ordinary hysteresis loops), and the vertical coils are entirely removed. If the two samples are of precisely the same magnetic quality, a simple rectilinear vibration will result; but the slightest difference between them will be exhibited by a characteristic curve. A. H.

1096. *Molecular Magnetic Susceptibilities.* **S. Meyer.** (Deutsch. Phys. Gesell., Verh. 1. 15. pp. 275–277, 1899.)—The author clears up some questions of priority between himself and du Bois, Wills, and Liebknecht. [See Abstracts Nos. 1922 (1899), and 528 (1900).] He points out the remarkable general agreement between the values found by the former by a wet method, and by himself by a dry method, the series of atomic magnetisms found by the former for Pr : Nd : Sa : Ga : Er being in the ratio of 3 : 5 : 12 : 26 : 37, and as found by himself, 2 : 5 : 10 : 23 : 40. The paramagnetism of yttrium and ytterbium is probably due to traces of erbium, which has a remarkably high susceptibility. E. E. F.

1097. *Change in the Size of Iron, Steel, and Nickel by Magnetisation.* **H. Nagaoka** and **K. Honda.** (Phil. Mag. 49. pp. 329–348, April, 1900.)—Changes in length of iron, steel, and nickel ovoids produced by the action of the magnetic field are noted by means of the optical lever—changes of volume by placing the ovoids in a glass tube containing liquid, provided with a capillary neck.

The continuous lines in the figure below show the relation between the field and the proportional elongation (or contraction), whilst the dotted lines



show the relation between the magnetic intensity and the elongation. It will be noted that initially iron and ordinary steel elongate when placed in a magnetic field, but that with increase of field contraction ultimately occurs. Like iron, annealed Wolfram steel shows a maximum elongation, but it indicates no signs of an ultimate resultant contraction. The paper also contains curves similar to those in the figure showing the relation between the increase in volume of the various ovoids, and the strength of the field; and the relation between the increase in volume and the intensity of magnetisation. Kirchhoff's equations show the relation between the changes in leng and volume, and the values of Young's Modulus and the Modulus

Rigidity; by means of these equations the effects of tension and torsion on the magnetisation of the ovoid can be tentatively calculated. Comparisons are made between the calculated and the actual effects. A. G.

1098. *Ship's Compass.* (Electrician, 44. p. 596, Feb. 16, 1900.)—In 1854 Scoresby suggested fixing the compass right aloft, so as to avoid errors due to iron in the ship. This idea is now carried out by Evoy in a compass which can be hauled up into the rigging. A carrying frame is provided with a system of cords and pulleys for maintaining the proper position, so that the compass swings clear. An automatic locking device is provided for the card. When hauled up, two hemispherical projections are engaged in corresponding cavities, thus fixing the frame and liberating the card. The card becomes locked at the instant that the compass begins to descend. Readings of the locked card are taken on deck. R. A.

1099. *Electric Tramways and Magnetic Observatories.* **v. Bezold.** (Elektrotechn. Ztschr. 21. pp. 161–164. Discussion, pp. 164–165, Feb. 22, 1900.)—Upon the basis of the researches of Eschenagen and Edler, at Potsdam and Spandau, the author pleads for the protection of magnetic observatories from disturbances due to earth returns of electric railways. He shows that terrestrial magnetism was the parent and precursor of electric telegraphy and of the whole of electro-technology, that it involves enormous commercial interests, and that it is in imminent danger of being made a science impossible to prosecute. For the purposes of modern navigation it is essential that magnetic charts should be republished every five years, and the revision cannot be successfully carried out without fixed points analogous to the fundamental points of a trigonometrical survey. In countries where, as in the United States, the boundaries of territories and states are fixed by the compass, endless legal difficulties are occasioned by slight errors in the magnetic variation. Earth returns have already ruined the work of the Washington, Toronto, Vienna, Nice, Copenhagen, and Batavia observatories; and others are threatened. It is practically impossible to secure sites away from possible disturbances, unless magneticians of high standing are to share the fate of lighthouse-keepers. Metallic returns appear to be the only efficient safeguard. E. E. F.

MEDICAL ELECTRICITY.

1100. *Voltaic Alternatives in the Treatment of Muscular Atrophies.* **C. Truchot.** (Archives d'Él. Médicale, 8. pp. 145–148, April, 1900. Paper read before the Association française, Boulogne.)—This monograph refers to an apparatus designed for the purpose of submitting a muscle to "voltaic alternatives." It consists of a reverser fixed upon a motor, the speed of the latter being regulated by means of a rheostat, and capable of attaining 40 revolutions a second. By means of this apparatus, instead of the simple muscular contraction produced at the opening or closure of a continuous current, a tetanisation of the muscle may be produced like that resulting from the application of a Faradic current. A further advantage of this arrangement is that the alternations do away with electrolytic action and the danger of scarring; and it is evident that the muscle, whether showing reaction of degeneration or not, will be excited by one or other of the changes. In support of the claims of his apparatus the author mentions the case of a be-

suffering from infantile paralysis in which it was employed, using 4 or 5 milliamperes and about 80 reversals a second. Tetanisation was complete; rhythmical contractions being secured by means of a pendulum interrupter. At the end of fifteen séances of ten minutes daily Faradic contractility was re-established in the muscles, and a fortnight later cure was complete. W. S. H.

1101. *Low-Tension Alternating Current Accident.* **A. Kolben.** (Elektrotechn. Ztschr. 21. pp. 183–184, Feb. 15, 1900.)—While the lighting dynamo of some potash works near Prague was under repair, the glow lamps were connected between one phase and the neutral wire of the triphase power plant working at 190 volts, and were thus on an alternating 110-volt circuit. One man, standing on an iron soda tank, with his boots soaked with soda and his bare hands probably wet with lye, is supposed to have slipped and to have touched one of the naked wires of a lamp. A hot wire voltmeter quite close to the spot afterwards indicated 96 volts between the wire and earth. Two of the man's fingers stuck to the wire, and as his fellows taking hold of his free right arm received shocks, five minutes may have elapsed before he was released. All attempts to revive him failed, although they were commenced at once and a physician was promptly summoned. The post-mortem disclosed mechanical abrasion on the left hand and proved the man to have been a hard drinker, but left the direct cause of death doubtful. Alcoholism probably rendered him particularly sensitive to electric shocks. H. B.

1102. *Treatment of Extensive Vascular Tumours by Electrolysis.* **J. Bergonié.** (Archives d'Él. Médicale, 8. pp. 106–115, March, 1900.)—These vascular tumours are classed according to their gravity or importance. In the first class are placed those which rise little or not at all above the surface of the skin. In the second are those formed by capillary vessels of new formation not differing from normal vessels, and showing neither dilatation nor sanguineous cavities. In the third class are placed "cavernous angiomata," in which there are cavities more or less like the cavernous tissue of erectile organs. The author takes for granted the universally recognised efficacy of electrolytic treatment of ordinary nævi. In the large cavernous variety, however, the prognosis is more grave, and the result less certain. Nevertheless it will prove very satisfactory to those who undertake it by the following method: The instrumentation consists of that always employed in every electrolytic operation, *i.e.*, a continuous current, a milliampere meter graduated from zero to 100 milliamperes, and a rheostat capable of varying very gradually the intensity of the current. With reference to the galvanic source, it is important not to work through too high a resistance, *i.e.*, to work with just such an amount of electromotive force as is necessary for the purpose in hand; 20 to 30 volts is quite sufficient. Two needles should be used, the bipolar method being the best. They will be as rigid as possible with a diameter from 0·5 to 0·8 of a millimetre, and usually about 8 centimetres long. With reference to the insulation of the needles, the following will be found a useful rule. Having decided what depth the needle is to be inserted in the tumour, half of that distance only must be left bare or uninsulated. In operating, choose the most salient points of the tumour to insert the needles. To be sure of a sufficient localisation current, the needles should not be more than 12 to 15 mm. apart. The intensity of the current and duration of the operation will depend up the case, but a proper result will seldom be obtained with less than

milliamperes, and a duration of at least 5 min. At each sitting at least 3 or 4 bipolar punctures ought to be made in a tumour of any size. Sometimes one sitting will be sufficient, but their number and frequency will depend upon the hardening of the electrolysed part, the cessation of pulsation in the tumour, and other evidences of the effect of the electrolysis.
W. S. H.

1103. *Electrolytic Treatment of Urethral Stricture.* **R. Newman.** (Archives d'Él. Médicale, 8. pp. 116–121. Discussion, pp. 121–123, March, 1900. Translated from the Journal of Electrotherapeut, New York, March, 1899.)—The author has successfully employed electrolysis in more than one thousand such cases during the course of thirty years. This treatment has proved successful beyond doubt. Many practitioners, not understanding the method, avoid it, because our medical colleges give little or no instruction in electrotherapeutics. The pathology of stricture is entered into, and it is pointed out that progressive dilatation is an ideal treatment in cases of slight pathological alterations in the mucous membrane ; but it is not competent to deal with submucous infiltrations and fibrous formations more or less profoundly situated. It is then explained that in the electrolytic method, as in the case of the decomposition of any compound body by electricity, acids and oxygen form at the positive pole producing coagulation, thereby acting as an acid, and leaving a hard elastic cicatrix. At the negative pole there appear hydrogen and bases of salts ; albumen is coagulated and absorption produced. This pole acts rather as a caustic alkali. It does not cause much pain during the application, and after the use of a very strong current a cicatrix remains which is soft and non-retractable. The very different results that follow electrolysis depend on the intensity of the current and the duration of the application. For surgical purposes the rule is as follows: Weak currents produce absorption, strong currents produce cauterisation and destruction of tissue. Therefore it follows that in the treatment of stricture weak currents ought to be employed—5 milliamperes or less—using the negative pole. What we aim at is chemical and galvanic absorption. The séances are short (5 to 20 min.) and repeated at a week's interval. If it is asked, what absorbs? and what is absorbed? the answer is that the galvanic current by the decomposition it brings about absorbs by degrees pathological formations which are encroaching on the calibre of the urethra. Several types of electrodes are employed, the most useful being one with a slight curve and an olive-shaped metallic tip. All the rest of the electrode is of course insulated. The region affected must in the first instance be thoroughly explored. The position of the patient is not a matter of much consequence, and anæsthetisation is not necessary as there is no pain. W. S. H.

1104. *Cinematoradiography of the Heart.* **H. Guilleminot.** (Archives d'Él. Médicale, 7. pp. 553–564, 1899.)—This paper describes an apparatus which enables the movements of the heart and arch of the aorta to be reproduced by means of Röntgen rays and the cinematograph. It is necessary to pass the Röntgen rays through the thorax at a given phase of the cardiac movement, and to repeat the operation a sufficient number of times. The latter necessity arises from the fact that radiography cannot like ordinary photography *instantaneously* take an image of any particular phase in a movement. The apparatus to effect these objects is briefly and technically described, and does not admit of abridgment. W. S. H.

1105. *Measurement of the Penetrating Power of Röntgen Rays by means of the Spintermeter.* **A. Béclère.** (Archives d'Él. Médicale, 8. pp. 153–157, April, 1900.)—The author is in the first instance careful to explain that the spark-measurer, or spintermeter (σπινθηρ, a spark), is in no way a new invention, nor even a new idea; it is only a rule or rod graduated in centimetres; but it will be found a useful addition to the radiographic outfit. It is well known that the penetrating power of Röntgen rays increases and decreases with the resistance of the tube—a resistance depending on the calibre of the tube, distance of electrodes, degree of vacuum, and qualities of the passing current. During the course of radiographic or radioscopic examinations, this resistance varies from one moment to another. It almost always increases, but sometimes it suddenly diminishes in consequence of the warming of the antikathode. These variations in resistance become evident through corresponding variations in the luminosity of the tube and distinctness of the shadows thrown upon the screen, but are only very imperfectly appreciated in this fashion; one of the reasons being that a personal element comes into play which is always undergoing change, that is to say, the sensibility of the retina alters; it may increase after remaining less than 20 minutes in the dark, in the proportion of 1 to 200. It is known that the best way of ascertaining the resistance of a tube is to ascertain what is known as the "equivalent spark." The spintermeter is only a detonator graduated to measure the length of the spark. It consists of a metallic rod divided into half centimetres, terminating in a point at one of its extremities, and an ebonite handle at the other. This rod moves easily in a metallic socket placed upon an insulating support, so that the point can be approximated or removed at will from another metallic point (fixed upon a second insulating stand) about 35 centimetres distant from the first. This is placed in circuit with the coil and tube. If there is a spark between the two fixed points the movable rod is withdrawn until there is no longer a spark at each discharge, and the scale marks the length of the spark and the corresponding resistance of the tube. If the resistance of the latter is not what is required, it can be increased or diminished by means of the Osmo-regulator of Villard,—an arrangement for introducing gas into the tube or removing it as desired. The spintermeter can be constructed so as to work either vertically or horizontally. W. S. H.

REFERENCES.

1106. *Dissymmetrical Currents in the Secondary of a Transformer, with a Wehnelt Interrupter in the Primary.* **O. M. Corbino.** (Accad. Lincei Atti, 8. pp. 359–365, 1899.)—Experimental details. Discussion as to the cause of the dissymmetry, whether due to the passage only of currents at make or to a phenomenon analogous to the electric arc. A. D.

1107. *Theory of Induction Coil.* **H. Armagnat.** (Écl. Électr. 22. pp. 121–125, Jan. 27, 1900.)—A theoretical discussion of the mode of action of an induction coil. Taking into account the condenser, induction, capacity, &c., the conclusion is once more deduced that mechanical interrupters should have as high a speed as possible at the moment of break. D. E. J.

1108. *Universal Galvanometer.* **O. Schöne.** (Zeitschr. Instrumentenk., Beib. pp. 13–15, Jan. 15, 1900.)—This galvanometer contains a combination of resistance binding screws and keys, which by different groupings enable E.M.F.'s, resistance insulation resistances, and current strengths to be measured. It is in fact a compl testing-set, Siemens and Halske being the makers. J. B.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1109. *Argon and its Combinations.* **Berthelot.** (Annal. Chim. Phys. 19. pp. 66–89, Jan. 1900.)—From 690 cc. of crude argon, after freeing from nitrogen by sparking with oxygen over potash, or with glycolic ether (one of the best absorbents of nitrogen) there resulted 455 cc. of the pure gas. From 5 to 10 cc. was confined over mercury in a tube enveloped in a large platinum or aluminium spiral. An inverted syphon filled with 10 per cent. sulphuric acid had its inner closed end pushed up into the gas tube. The spiral and syphon being made the two poles of an induction coil, the current traversed the two thicknesses of glass and the annular space of gas, avoiding strong sparks as in an ozoniser. About 0·1 or 0·2 cc. of the liquids under trial was introduced, the very slight solubility of the gas being neglected. The results varied with tension, temperature, and other circumstances. Ethene, glycolic ether, aldehyde, acetone, and compounds of the fatty series generally, while suffering some decomposition, showed no absorption of argon, and no luminosity in 20–24 hours. With the benzene group combination occurred easily, with a varying green luminosity showing the lines of A, Hg, C, and H, and an absorption from 1 per cent. (aniline) to 8 per cent. or more (benzene). Ring compounds of the C_4 and C_5 groups gave intermediate results. Further experiments were made with benzene in regard to its polymerisation and the formation of *phenylmercurargon*, also with carbon disulphide: 34 of the latter fix 2 of argon, forming a yellowish amorphous, solid, from which heat regenerates a small quantity of argon. From the liberation of argon from some minerals the author argues the existence of *argonides* of the metals.

S. R.

1110. *Melting-Point of Chloral Hydrate.* **C. G. L. Wolf.** (Journ. Phys. Chem. 4. pp. 21–32, Jan., 1900.)—The author describes a number of experiments on the melting of chloral hydrate, and concludes that the differences observed in the melting-point are due to dissociation phenomena and not to the presence of two different modifications in the melted mass. The two forms described by Pope—namely, the long uniaxial needles obtained on cooling fused chloral hydrate under a microscope cover slip and the monosymmetric plates deposited from a solution in chloroform—show identical behaviour on heating. The melting-point of the undissociated substance is above 72°, at which temperature the sublimation pressure is about 22 mm. The triple point for chloral hydrate and its dissociation products is about 47°.

T. H. P.

1111. *Solubility of Carbonic Acid.* **C. Bohr.** (Ann. d. Physik, 1. 2. pp. 244–256, Feb., 1900.)—The solubility of carbonic acid in alcohol was determined between the temperatures of 45° and — 12° by precipitating the acid from the solution with baryta water, and between — 12° and — 67° by an absorptiometric method. The formula $a(\mathrm{T}-n) = \mathrm{K}$ can be used as an interpolation formula for all temperatures, except the portion below — 27° where the fall of n is too great. The following are some of the absorptions found :—

Temperature	—65	—25	—10	0	10	20	30	40

The coefficient of evasion, *i.e.*, the amount of carbonic acid penetrating 1 sq. cm. of the surface per minute was found to be 0·574 at standard temperature and pressure. The coefficient of invasion was similarly found to be 2·375.

E. E. F.

1112. *Heat of Combination of Copper with Zinc.* **T. J. Baker.** (Chem. Soc., Proc. 15. pp. 195–196, 1899.)—The author measures the difference between the heat of solution of the alloy and the sum of the heats of solution of the pure metals in the same proportions. The solvents used were chlorine-water (0·15 normal) and nitric acid (HNO_3, $3H_2O$). From 0 to 30 per cent. of copper, no heat of combination could be detected. From 30–62 per cent. of copper, the curve (*i.e.*, the heat of formation of 1 grm. alloy plotted against percentage of copper) rises to an ill-defined maximum. From 62–100 per cent. of copper the curve gradually sinks to zero. F. G. D.

1113. *Reversible Photochemical Processes.* **R. Luther.** (Zeitschr. Phys. Chem. 30. pp. 628–680, Dec. 30, 1899.)—Those chemical actions in which light affects not merely an increase in the velocity of a chemical reaction which is capable of proceeding spontaneously, but causes an actual disturbance of the chemical equilibrium involving an expenditure of energy, can be employed as a means of determining the relations prevailing during the transformation of radiant into chemical energy. In the reversible photochemical process examined by the author—that of the darkening of silver chloride or bromide—when the equilibrium existing between the free halogen and the dark reduction product of the silver haloid is disturbed, the change in the intensity of the chemical energy can only be compensated by an equivalent but opposite change of the light intensity.

In order to examine the relation existing between the intensity of light and the equilibrium pressure of the halogen, glass plates on the surfaces of which the silver haloid has been slowly deposited, are illuminated on the back surface by light passing through a tube photometer containing 16 tubes, the front side being in contact with solutions of the free halogen; the extent of the light action is shown by the number (N) of black spots produced on the plate. The curves connecting the logarithm of the concentration (C) with N, both for silver chloride and bromide, are not rectilinear but are convex towards the axis of N. To test the theoretical relation $A = aI + b$ (A being the affinity of the reaction, I the intensity of the light, proportional to N, and a and b constants), the affinity A is measured by determining the E.M.F. of a halogen concentration cell; between the limits of concentration used above, it is found that the E.M.F., and consequently A, is proportional to log C. Hence it follows that A is not proportional to I, and the relation $A = aI + b$ does not hold. This discord between theory and experiment the author concludes is due to either inaccuracy or incompleteness of the theory or to some constant experimental error. Attempts were made, without success, to obtain light phenomena from the bleaching by chlorination or bromination, in the dark, of the blackened silver haloid.

To bleach either the latent or visible image (in absence of an organic medium), the oxidation-potential just sufficient is, in the case of silver chloride, 1·44, and for the bromide 1·14 volts; the latent and visible images have hence very probably the same composition. To investigate the chemical nature of the blackened product, the oxidation potentials of a halogen solution are determined after it has been shaken up with increasing quantities of powdered silver. It is found that the potential remains unchanged until almost exact

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one-half as much silver has been added as is required by the formula AgCl or AgBr ; at this point the potential suddenly rises to 1·44 volts in the case of the chloride, and to 1·14 in the case of bromide of silver, these values remaining constant until the amount of silver added is equivalent to the halogen present. This behaviour points, with a very high degree of probability, to the existence of the compounds Ag_2Cl and Ag_2Br, and also shows that other silver sub-haloids, such as Ag_3Cl_2 for example, do not exist ; it also indicates that the darkened product of the action of light on the silver haloids, in absence of organic matter, has the composition Ag_2Cl (or Ag_2Br).

The author works out a theory of reversible photochemical processes from the laws of radiation and of energy ; this he only advances as a working hypothesis, which is as yet by no means confirmed by experimental data.

T. H. P.

1114. *New Sulphate of Magnesium and Potassium.* **J. H. van't Hoff** and **N. Kassatkin.** (Preuss. Akad. Wiss. Berlin, S. ber. 51. and 52. pp. 951–958, 1899.)—This is another of the series of papers on the Stassfurt salt deposits. [See Abstracts, Nos. 1939 (1899) and 226 (1900).] While experimenting on the double sulphates of magnesium and potassium the authors have discovered a hitherto unknown salt having the formula—

$Mg_4K_2(SO_4)_5 . 5H_2O$, which stands in the same relationship to $4(MgSO_4) . 5H_2O$ as Schönite, $MgK_2(SO_4)_2 . 6H_2O$, stands to $MgSO_4 . 6H_2O$, and as Leonite, $MgK_2(SO_4)_2 . 4H_2O$, stands to $MgSO_4 . 4H_2O$.

This new salt is formed by heating a mixture of $MgSO_4 . 6H_2O$ and Leonite to 72·5°, at which temperature a considerable expansion takes place, a corresponding contraction following immediately on cooling. It may also be formed by heating to about 80° a mixture of finely powdered potassium and magnesium sulphates in the proportions of 1 molecule to 4 molecules, the heating being done under oil to prevent drying. The long needle crystals removed from the mother liquor at about 80° and dried gave on analysis a formula in close agreement with the above.

J. B. H.

1115. *Cryoscopic Observations.* **K. Auwers** (with **F. H. Betteridge, W. Bartsch, M. Dohrn,** and **H. M. Smith.**). (Zeitschr. Phys. Chem. 32. pp. 39–62, Feb. 6, 1900.)

1. *Hydroxyketones in Naphthalene.* With the exception of *p*- nitrobenzoyl-*p*- cresol which shows an abnormally *low* molecular weight decreasing as the concentration increases, all the orthohydroxyketones examined behave normally, in accordance with the laws already stated. (See 1900, Abstract No. 544.) The parahydroxyketones show the usual abnormal behaviour of phenols.

2. *Substituted Phenols in Naphthalene.* The abnormal behaviour of methyl *p*-hydroxybenzoate is very largely reduced by a halogen atom in the ortho-position to the hydroxyl group, the influence of the three halogens being almost identical. Para- and meta-hydroxybenzaldehyde are strongly abnormal, but their substitution products only in a much less degree. Of the divalent phenols, pyrocatechol and resorcinol are both abnormal, but the monomethyl ether of pyrocatechol is quite normal.

3. *Nitroso-compounds in Naphthalene.* Nitrosobenzene behaves quite normally, but derivatives of *p*- nitrosoaniline show an abnormal behaviour which is perhaps an indication that they have a quinonoid structure.

cryoscopic values when dissolved in dimethyl oxalate, but the deviations are only small, especially in the case of phenols. The depression constant is 50.

5. *p- Azoxyanisole as a Solvent.* This substance melts at 117° to "liquid crystals," which disappear at 134·5°, when the liquid becomes isotropic; cryoscopic determinations can be carried out at the transition-point from liquid crystal to true liquid, and the depression-constant was found by Schenck to have the extraordinary value K = 764. This value is probably too high, and a redetermination has given K = 545 as a mean value for five substances. Using this value normal results were obtained even with substances which behave abnormally in other solvents. T. M. L.

1116. *Stassfurt Salt Deposits and Saturated Solutions of Chlorides.* **H. A. Wilson.** (Preuss. Akad. Wiss. Berlin, S.ber. 51. and 52. pp. 954–955, 1899.)—Suppose the saturated solution of chlorides to be as follows:—

$$1{,}000H_2O \text{ a } Cl_2Na_2 \text{ b } Cl_2K_2 \text{ c } Cl_2Mg \text{ d } SO_4Mg,$$

then the author concludes that—

$$b + \frac{c}{5} = \text{const.}$$

The following table gives the experimental proof:—

	K_2Cl_2	$MgCl_2$	$K_2Cl_2 + \frac{MgCl_2}{5}$
NaCl and KCl	19·5	0	19·5
NaCl, KCl and Glaserite	20	0	20
„ „ and Carnallite	5·5	70·5	19·6
„ „ Glaserite and Schönite	16	18·5	19·7
„ „ Schönite and Leonite	14·5	25·5	19·6
„ „ Leonite and $MgSO_4.6H_2O$	13	30·5	19·1
„ „ $MgSO_4.6H_2O$ and $MgSO_4.5H_2O$	6·5	63	19·1
„ „ $MgSO_4.5H_2O$ and Carnallite	6	68	19·6
„ „ and $MgSO_4.6H_2O$	7·8	55·8	19
„ „ Schönite and $MgSO_4.6H_2O$	9·5	42·5	(18)
„ „ in 20 per cent. $MgCl_2$	9·5	47·5	19

J. B. H.

1117. *Molecular Weight of Sulphur by the Ebullioscopic Method.* **L. Aronstein** and **S. H. Meihuizen.** (Archives Néerlandaises, 3. pp. 89–130, 1899.) —In view of the discrepancies between existing determinations of the molecular weight of sulphur in solution, the authors have carried out a large number of experiments by the ebullioscopic method, using as solvents carbon bisulphide, benzene, toluene, xylene, naphthalene, phenol, and sulphur chloride, having boiling-points ranging from 46° to 214°. Some modifications in the apparatus employed are described, and the experimental results are recorded in the form of tables and curves. The following general conclusions are arrived at: There is no distinct difference between the molecular weights of sulphur determined at temperatures below and above the point of transformation of the rhombic into the triclinic modification, and this remark also applies to determinations above and below the melting-point. Thus, measurements with toluene at 110° point to the existence of the molecule S_7, whilst those with xylene at 139° give results intermediate between S_7 and S_8. In carbon bisulphide sulphur has a molecular weight in accord with the formula S_8 and not S_9 as stated by Orndorff and Terrasse. With regard to

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the use of sulphur chloride by these observers, who obtained therewith the value S_2, it is shown that this liquid is partially dissociated at its boiling-point into chlorine and sulphur. It is therefore ill adapted for molecular weight determinations and the results obtained with it are untrustworthy.

N. L.

1118. *Catalytic Action of Neutral Salts.* **H. Euler.** (Zeitschr. Phys. Chem. 32. pp. 348–359, Feb. 20, 1900; from the Öfversigt af K. Svenska Vetenskaps Akademiens Forhandlingar, 5, 1899.)—Neutral salts have the greatest effect in accelerating the inversion of cane sugar by acids when the concentration of the acid is small; the effect is slightly less at higher temperatures, and is slightly greater when the concentration of the sugar is large. The influence of neutral salts in the hydrolysis of esters by acids is similar in magnitude and in character, but in the saponification of esters by alkalies neutral salts often have a retarding, and not an accelerating effect. It is suggested that the action of neutral salts may perhaps consist in increasing the degree of dissociation of the water in which they are dissolved.

T. M. L.

1119. *Calculation of Ionisation of Complex Solutions of given Concentration, and the Converse Problem.* **J. G. MacGregor.** (Nova Scotian Inst., Trans. 10. pp. 67–78, 1898–1899.)—The author describes a modified form of his graphical method for determining the degrees of ionisation in solutions containing two electrolytes possessing a common ion.

Denoting the electrolytes by 1 and 2, the concentrations (in grm.-equivalents per litre) by N_1 and N_2, the degrees of ionisation by a_1 and a_2, and the dilutions (in litres per grm.-equivalent) of the component isohydric solutions by V_1 and V_2, we have the equations:—

$$\frac{a_1}{V_1} = \frac{a_2}{V_2} \qquad (1)$$

$$N_1 V_1 + N_2 V_2 = 1 \qquad (2)$$

$$\frac{a_1}{V_1} = f_1(V_1) \qquad (3)$$

$$\frac{a_2}{V_2} = f_2(V_2) \qquad (4)$$

If we are given N_1 and N_2 and wish to obtain a_1 and a_2 there are various graphical methods whereby the desired result may be obtained. For example, as follows: Plot the curves (3) and (4) using ionic concentrations as abscissæ and dilutions as ordinates. Then plot a new curve such that its ordinate is equal to N_1 times, the corresponding ordinate of (3) plus N_2 times the corresponding ordinate of (4). By "corresponding" is meant "having the same abscissa." Draw the straight line $V = 1$. Through the point where it cuts the last-mentioned curve draw a vertical straight line. This line cuts (3) and (4) in two points. The corresponding ordinates are the values of V_1 and V_2, and the common abscissa the value $\frac{a_1}{V_1} = \frac{a_2}{V_2}$. The problem is therefore solved. Other very similar methods of effecting a graphical solution are discussed by the author.

To solve the converse problem the author points out that it is necessary to have some other datum besides the degree of dissociation. He then describes how to effect the solution graphically according as the other datum is (1)

to the two electrolytes, (3) total concentration or difference of the two concentrations, (4) a given value for the conductivity of the solution.

Finally the author discusses the methods employed by Schrader (Zur Elektrolyse von Gemischen, Berlin, 1897), and by Kay (Proc. R. S. Edin. 22. 502, 1898–99), for calculating ionisation-coefficients and contrasts them with his own method. F. G. D.

1120. *Relation of Viscosity of Mixed Solutions of Salts to their Ionisation.* **J. Barnes.** (Nova Scotian Inst., Trans. 10. pp. 113–128, 1899–1900.)—This investigation is an application of MacGregor's method. The author first calculates from known data the molecular conductivities at infinite dilution for 25° C. in the case of aqueous solutions of KCl, NaCl, $BaCl_2$, Na_2SO_4, K_2SO_4, and $CuSO_4$, and hence the ionisation-coefficients for various dilutions at that temperature. Using the equation $P = P_w + k(1-a)n + lan$, where $P =$ viscosity of solution, $P_w =$ viscosity of water, $n =$ concentration in grm.-equivalents per litre, $a =$ degree of dissociation, k and $l =$ two constants; the values of k and l are calculated by means of the viscosity measurements of Reyher and Wagner and the ionisation coefficients already obtained.

For mixtures obtained by the mixing of equal volumes of equivalent solutions, the general equation for dilute complex solutions:—

$$P = P_w + \frac{1}{p}\left\{ [k_1(1-a_1)n_1 + l_1 a_1 n_1]\frac{v_1}{v_1+v_2} + [k_2(1-a_2)n_2 + l_2 a_2 n_2]\frac{v_2}{v_1+v_2} \right\},$$

where $p =$ ratio of volume of mixture to sum of volumes of constituent solutions, v_1, $v_2 =$ volumes of constituent solutions, reduces in this case to $P = P_w + \frac{n}{2}\left\{ k_1(1-a_1) + l_1 a_1 + k_2(1-a_2) + l_2 a_2 \right\}$, since $p = 1$. The k's and l's in this equation have the values calculated for the simple solutions. Hence P, the viscosity of the complex solution may be calculated if a_1 and a_2 can be obtained. The values of a_1 and a_2 are calculated by using a slightly modified form of MacGregor's graphical method, as follows: If one employs specific conductivity and concentration instead of ionic concentration and dilution respectively, the equations given by MacGregor (see preceding Abstract) may be written in this form:—

$$k_1 = \frac{\mu_{\infty 1}}{\mu_{\infty 2}} k_2$$

$$\frac{N_1}{C_1} + \frac{N_2}{C_2} = 1 \quad \ldots\ldots (a)$$

$$k_1 = f_1(C_1) \quad \ldots\ldots (b)$$

$$k_2 = f_2(C_2) \quad \ldots\ldots (c)$$

This system is solved graphically as follows: Plot the curve (b), using specific conductivities as abscissæ and concentrations as ordinates. Plot (c) in a similar manner on the same paper, but give the curve a "parallel" displacement by multiplying the value of each specific conductivity by the factor $\frac{\mu_{\infty 1}}{\mu_{\infty 2}}$. Find by inspection two points, one on each curve, having a common abscissa and ordinates which satisfy equation (a). In this way, C_1, C_2, k_1 and k_2 are obtained, and hence a_1 and a_2 from the equations $\frac{a_1}{V_1} = \frac{k_1}{\mu_{\infty 1}}$, $\frac{a_2}{V_2} = \frac{k_2}{\mu_{\infty 2}}$. The values so calculated for the viscosities of solutions containing two salts with a common ion are compared with the experimental results of Kanitz. The agreement between the two appears to be tolerably good. **F. G. D.**

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1121. *Chemical Equilibrium in a System containing Four Gases.* **H. Pélabon.** (Comptes Rendus, 130. pp. 576–579, Feb. 26, 1900.)—If mercury selenide is heated above 500° in an atmosphere of hydrogen it is partially reduced in accordance with the reversible equation—

$$HgSe + H_2 \rightleftarrows H_2Se + Hg.$$

If the partial pressures of these substances be p_1, p_2, p_3, and p_4 respectively, then $\frac{p_1 p_2}{p_3 p_4} = f(T)$. In presence of an excess of solid mercury selenide p_1 becomes a constant for each temperature, whilst if no excess of mercury is present $p_3 = p_4$, and the equation becomes $\frac{p_2}{p_3^2} = f(T)$; this equation has been verified for three pressures of hydrogen at 540°. In presence of an excess of mercury p_4 becomes a function of the temperature, and the equation is $\frac{p_2}{p_3} = f(T)$; the reduction of the selenide is largely prevented by the excess of mercury —a result which has been verified by experiment. T. M. L.

1122. *Equilibria with Two Liquid Phases in Systems composed of Water, Alcohol, and an Alkaline Salt.* **B. R. de Bruyn.** (Zeitschr. Phys. Chem. 32. pp. 63–115, Feb. 6, 1900.)—The following systems were studied: (I.) Ammonium Sulphate, Ethyl alcohol, Water. (II.) Potassium Carbonate, Methyl alcohol, Water. (III.) Potassium Carbonate, Ethyl alcohol, Water. (IV.) Sodium Sulphate, Ethyl alcohol, Water.

The contents of the paper may be summarised as follows:—

1. *Quadruple Curves investigated.*

System I.—Two liquid phases, solid $(NH_4)_2SO_4$. Below 8° two stable phases cease to coexist.

System II.—Two liquid phases, solid salt hydrate. The two liquid layers become identical at −35°.

System III.—Two liquid phases, solid salt hydrate. A critical solution-temperature was not observed.

System IV.—One liquid phase, $Na_2SO_4 . 10 H_2O$, Na_2SO_4. Investigated from 32·5° to 10°.

2. *Triple Curves investigated.*

System I.—(*a*) One liquid phase, solid $(NH_4)_2SO_4$.

(*b*) Two conjugate liquid phases. Separation of a homogeneous solution produced by cooling or heating, according as the alcohol concentration is high or low. Mixtures of intermediate concentration become homogeneous on heating, but separate again on further rise of temperature.

System II.—Two conjugate liquid phases. On warming, an initially homogeneous mixture separates into two layers.

System III.—Two conjugate liquid phases. Mixtures of high or low alcoholic concentration behave as in I. (*b*). Intermediate mixtures on rise of temperature become at first homogeneous, then separate, and finally become homogeneous again.

System IV.—(*a*) One liquid phase and solid $Na_2SO_4 10H_2O$, Na_2SO_4, or $Na_2SO_4 7H_2O$. The last combination is supersaturated with respect to the decahydrate.

(*b*) Two conjugate liquid phases. This combination is always unstable, being at lower temperatures supersaturated with respect to decahydrate and at higher temperatures with respect to anhydrous salt. A homogeneous solution separates into two layers on cooling.

8. The author proves the existence of the hydrates :—

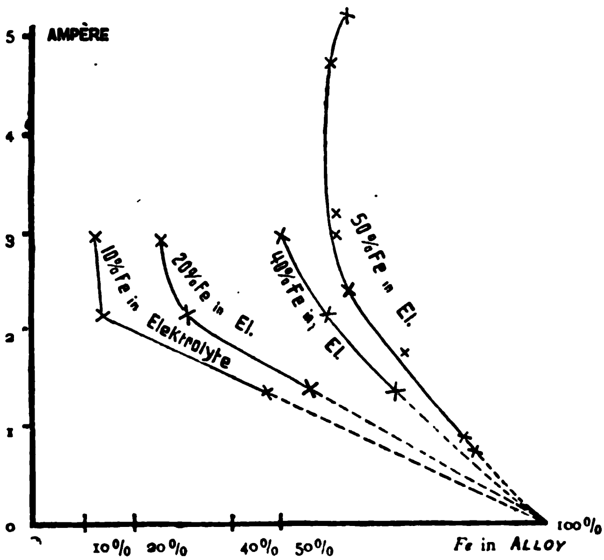
$$K_2CO_3 . 1\frac{1}{2}H_2O$$
$$K_2CO_3 . 2H_2O$$

and confirms the known fact that no stable hydrate of the formula $Na_2SO_4 . H_2O$ exists.

The paper contains a very great mass of data, and very complete bibliographical references. F. G. D.

1123. *Electro-deposition of Copper from Alkaline Solutions.* **S. Cowper-Coles.** (Elect. Rev. 46. pp. 255–256, Feb. 16, 1900.)—A description with figures of a plant erected at the works of the *Société des Mines et Fonderies de Zinc de la Vielle-Montagne* in Belgium for electro-depositing copper upon zinc sheets. Anodes of rolled copper are used, with an electrolyte containing the double cyanide of copper and potassium. This solution is made up to a strength of 1·12 sp. gr. at 15° C., and is worked at a temperature of 150° F. A current density of 10 amperes per square foot, and an E.M.F. of 1·6 volts are employed. The electrolyte is maintained at its proper strength by circulating through a filter containing finely divided copper. J. B. C. K.

1124. *Electro-deposition of Alloys.* **H. W. Toepffer.** (Zeitschr. Elektrochem. 6. pp. 342–344, 1899.)—Mixed solutions of the simple sulphates, of the double ammonium sulphates, and of the oxalates were used as electrolytes in the author's experiments, and the following alloys were deposited : Iron-



nickel, iron cobalt, iron zinc, and cobalt-nickel. An attempt was made to obtain in a similar manner an alloy of iron and copper, but this failed.

The results obtained did not accord with the theoretical assumption that as the E.M.F. increased gradually from zero, the salt with the higher decomposing value would, from a certain point onwards, join to an increasing extent in the transfer of the current across the cell. As the E.M.F. and

current increased, the metal requiring the higher E.M.F. to bring about its deposition was found to be deposited in a *diminishing percentage* at the kathode.

As an illustration of this phenomenon, the author gives the results obtained with an electrolyte containing ferrous and nickel sulphates, in the form of a diagram, and this is reproduced above. As the current and E.M.F. increase less iron is deposited, although ferrous sulphate has a higher decomposing value than nickel sulphate. The dotted portions of the curves are projections, and serve to indicate that as the current and E.M.F. approach zero, the alloy will contain chiefly iron and little or no nickel.

Details of the experiments with the other metals named above are given. In explanation of the anomalous results obtained, the author puts forward the suggestion that the noble metals—of which nickel is one—very readily form complex anions, and that possibly the salts of these noble metals do not dissociate very readily on solution in water. The amount of salt in solution in this case would therefore be no guide to the number of ions ready to take part in electrolytic work. J. B. C. K.

1125. *Electrolytic Hypochlorites.* **A. Sieverts.** (Zeitschr. Elektrochem. 6. pp. 364–370, Jan. 4; and 374–378, Jan. 11, 1900.)—The author summarises the results of recent work upon the best conditions for electrolytic hypochlorite production as follows:—

(1) The maximum concentration obtainable by electrolysis is between 0·5 and 0·6 grm. oxygen as hypochlorite per 100 cc. Beyond this point chlorate is alone produced (Haber and Grinberg. Müller). (2) A high current density is favourable for hypochlorite production (Oettel). (3) A high temperature is unfavourable for hypochlorite production (Oettel). (4) The concentration of the original salt solution used does not affect the result, provided that the electrolyte contains from 58–116 grms. of common salt per litre, or an equivalent amount of the other salts.

All of these conditions harmonise with the theory of hypochlorite formation in the electrolytic cell, recently advanced by Foerster; but the second is in direct conflict with results obtained by Schoop, and the author, at Foerster's instigation, has undertaken the investigation of this point again. A description and sketch of the apparatus used is given. Platinum was used as anode material and iron as kathode. The methods of analysis used for determining the oxygen present as hypochlorite and as chlorate in the electrolysed solutions are described. Solutions of potassium chloride and of calcium chloride were used as electrolytes. The results obtained are reduced to a common form, and given in two tables. In each case the yield of hypochlorite increased with the current density, thus confirming the correctness of Oettel's results. In the course of the investigation it was found that the low current efficiency of the hypochlorite cell is due chiefly to reduction of previously formed hypochlorite by hydrogen at the kathode, and that under correct conditions of work, only a very small portion of the loss is due to the formation of chlorate, or to escape of gaseous chlorine at the anode. The author states that in all comparative investigations of this kind, it is imperative that equal current and equal flow of electrolyte should be maintained through the cell during the electrolyses. The time limit of the experiments is of no importance and should be neglected.

The second portion of the author's paper relates to the question of the high bleaching value of solutions of hypochlorite prepared by electrolysis. Foerster and Bischoff have ascribed this high value to the presence of free

hypochlorous acid in the electrolysed solution. The direct proof of this was, however, impossible by chemical means until recently, when a new method of analysis worked out by Jorre was shown to yield reliable results if applied to solutions containing hypochlorous acid in presence of its salts. Solutions of potassium chloride, sodium chloride, and calcium chloride were used for preparing the bleaching solutions. The apparatus resembled that used in the first set of investigations. With the first two salts the yield of hypochlorite was small, and the chief loss was traced to kathodic reduction. The yield with calcium chloride was, however, much higher, and confirmed the results obtained by Oettel and others.

Applying the new method of analysis to these electrolysed solutions, it was found that the theory of Foerster and Bischoff was correct, and that all contained a large portion of their available oxygen in the form of free hypochlorous acid. In the case of the calcium chloride solution, the proportion was highest and amounted to 50 per cent. This solution was found to be less stable than the other two solutions when exposed to the air. In many cases free chlorine is present in the solutions, and this must be removed before Jorre's test for free hypochlorous acid can be applied. A special experiment made with a solution containing 8 grms. of sodium chloride and magnesium chloride = 2 grms. of sodium chloride, was found to yield 95 per cent. of the available oxygen as free hypochlorous acid. This solution proved, in accordance with the theory, a *most energetic* bleaching agent.

Attempts were made to carry out similar experiments with solutions containing magnesium chloride alone, but it was found impossible to remove the free chlorine from the solution after electrolysis, by aeration, and the application of Jorre's method for determining the amount of free hypochlorous acid present was therefore impossible. J. B. C. K.

1126. *Electrolytic Preparation of Indulin Dyes.* **E. C. Szarvasy.** (Zeitschr. Elektrochem. 6. pp. 403–407, Feb. 1, 1900.)—The electrolysis of fused aniline hydrochloride results in the formation of azophenin and colouring matters of the indulin class. The best results are obtained at 160°, using an anode current density of about 0·8 ampere per square decimetre. Mainly of chemical interest. N. L.

1127. *Ozone Generator.* (Elekt. Runds. 17. pp. 89–90, Feb. 1, 1900.)—Otto's apparatus for producing chemical effects by means of high-tension discharges do not contain any dielectric but air, and one or both electrodes or some other parts are movable. Within a cylindrical casting provided with inward projections, a disc, fitted with points, turns about a vertical axis. The air enters on one side through a distributing sieve and leaves on the opposite side. When the inner electrode is turned, discharges take place as the points approach the projections. For alternating currents at 50,000 volts the points are replaced by a cast screw, varnished or covered with a non-oxidisable metal. Both electrodes may also be stationary and separated by a revolving cylindrical screen, out of which sectors are cut. If the distance is normally too large for any discharge to pass, the screen is made of a conductor; if the electrodes are near one another, the screen consists of insulating material. H. B.

1128. *Stassano Process for the Electro-metallurgical Production of Iron.* **F. P. Mann.** (Scientific American, 82. p. 68, Feb. 3, 1900.)—This process for the production of iron and steel has been tested on a practical scale at

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Rome, with favourable results. The furnace worked with Camonica ore, and utilised 100 H.P. In form the furnace resembles the ordinary blast furnace, the carbons for supply of the electric current being inserted horizontally, just above the hearth. The ores to be used are roasted, ground, and mixed with charcoal and pitch, before being placed in the furnace. Oxides of manganese, nickel, or chromium may be added during the grinding and mixing operations, in order to produce an iron or steel containing small amounts of these metals. It is estimated that one ton of metal can be produced in the Stassano furnace by the expenditure of 3,000 I.H.P. hours. Details of the thermal calculations upon which this estimate is based are given by the author. Three thousand H.P. hours can be generated in Italy at a cost of only 18 lire, and the whole process of iron production in the Stassano furnace can be carried out at a cost of 100 lire per ton, as compared with 160 lire by the ordinary blast furnace process.

A company has been formed to build a large works for operation of the process in the valley of Camonica; and three furnaces, each of 500 H.P. capacity, are to be forthwith erected at this place. It is expected that an output of 4,000 tons of iron and steel per annum will be attained when the works are completed. Two diagrams of the furnace accompany this description of the process. J. B. C. K.

1129. *Electric Furnaces, with Special Reference to the Production of Calcium Carbide.* B. **Carlson.** (Zeitschr. Elektrochem. 6. pp. 418–419, Feb. 8, and 429–434, Feb. 15, 1900.)—This is in the main a comparison between arc-furnaces and resistance-furnaces (in which heat is generated by the interposition of a fluid resistance, *e.g.*, the melted calcium carbide itself); and between continuous and intermittent-running of the furnaces. The resistance furnace cannot well be worked intermittently; but has the advantage that it consumes less electrode carbon and may therefore be run longer without intermission. On the other hand, the resistance varies greatly, and the current and, therefore, the temperature, are less under control; the lime and carbon mixture floats on the fluid carbide, and is thus not so well placed as in the arc-furnace where it is exposed to the full heat of the arc; whilst continuous currents must not be used, as they tend to cause electrolysis and hence volatilisation of calcium. *Continuous* furnaces have the disadvantage that the molten carbide comes in contact with the furnace-lining, which must therefore be more refractory in character (and must not, as in intermittent furnaces, consist of chamotte). Again, in consequence of the slag-like (viscous) character of the fluid carbide, and of its low specific heat, the temperature must be raised far above that at which the carbide flows freely (3,500°–4,000° C.) in order that it may be tapped, whilst in intermittent furnaces a temperature of 2,800°–3,000° C. suffices for the work; the proportion of dissociation in the continuous furnace is thus greater, calcium distils off, and the yield of carbide is lower, whilst a greater heat-expenditure is necessary. In practice the fusing-point is lowered by the addition of lime, but this gives a less pure carbide. The slow cooling of the charge in the *intermittent* furnace is economical because the reaction between lime and carbon continues markedly even at a temperature of 1,200°–1,500° C., and is therefore carried on economically during the cooling (by the waste-heat of the carbide already formed) in a portion of the charge not already treated; moreover, free calcium, which often exists dissolved in the carbide (even up to 10 per cent.), combines with free carbon during slow-cooling, but is prac-

The loss of heat by radiation and convection also is necessarily greater in the hotter (continuous) furnace than in the other. Calculation in the case of a furnace covered with iron plates having a superficial area of 7·5 sq. m. showed (according to Peclet's formula) that in an intermittent furnace of which the outside was at a temperature of 100° C., the loss from these causes amounted to 8,197 calories per hour, or 9·46 kilowatt hours, which is equivalent to 6·3 per cent. of the energy introduced into the furnace. A continuous furnace of the same material and dimensions would have lost 3·5 times as much. In practice the loss is reduced to about twice instead of 3·5 times the magnitude by building thicker walls and altering the conditions accordingly.

The second paper is principally devoted to calculations of relative efficiency. The specific heats at different temperatures of the various materials concerned are first calculated, for carbon and lime (by extrapolation where necessary), from Violle's formula, $S_C = 0·355 + 0·00006\,t$, and Gin's formula (for atomic heat), $S_{CaO} = 11·4 + 0·001\,t$, respectively, and for calcium and calcium carbide, with the aid of Kopp's law, as follows: $S_{CaO} - S_O = S_{Ca}$, and $S_{CaC_2} = S_{Ca} + 2S_C$, the atomic heat of oxygen being taken as constant at 4·0. The numbers obtained are as follows :—

Temperature.	Specific Heat of—			
	C.	CaO.	Ca.	CaC_2.
0° C.	0·355	0·2036	0·185	0·247
1,000	0·415	0·2214	0·210	0·271
1,500	0·445	0·2303	0·223	0·296
2,000	0·475	0·2393	0·235	0·325
2,500	0·505	0·2482	0·248	0·344
3,000	0·535	0·2571	0·260	0·363
3,500	0·565	0·2660	0·273	0.381

Using these figures calculations are made in detail to ascertain the actual expenditure of heat in continuous and intermittent furnaces. The final results, including loss by radiation and convection from the furnace-walls, are given in the following table, where *y*, *z*, and *u* represent the respective allowances to be made for the as yet unknown latent heats of fusion of the carbide and lime :—

Carbide containing CaC_2, per cent. (the rest = CaO.	Continuous Furnace.		Intermittent Furnace.		Proportion of the yield of Int. Furnace given by Cont. Furnace per cent.
	K.w. hours per kgrm. CaC_2.	Kgrm. CaC_2 per k.w. day.	K.w. hours per kgrm. CaC_2.	Kgrm. CaC_2 per k.w day.	
100	$3·92 + y$	$6·1 - z$	2·95	8·1	$75·3 - u$
86	$3·52 + y$	$6·8 - z$	2·62	9·1	$74·0 - u$
76	$3·25 + y$	$7·4 - z$	2·37	10·1	$73·5 - u$

These numbers may be considered theoretical maxima, any disturbi causes not here allowed for acting adversely, nevertheless there are cases record in which they have been very nearly reached in practice. Errors d

ignorance of the exact conditions at the temperatures used, although affecting the accuracy of the numbers themselves, do not influence the comparison between the two classes of furnace, any errors being constant. The teaching of these theoretical figures is confirmed by practice, for while an average of 4·5 kgrms. of 76 per cent. carbide per k.w. day is not exceeded in continuous-furnace work, intermittent furnaces, such as that of the *Deutsche Gold und Silber Anstalt*, give 5·8 to 6·5 kgrms. The fact that those who have tried continuous furnaces are now reverting to the use of intermittent furnaces also confirms this. Finally the author shows that the product of the continuous furnace is not necessarily uniform, nor does the intermittent furnace demand the employment of a larger staff of workmen. W. G. M.

1130. *Apparatus for use in Experimental Fused Electrolysis.* **A. A. Beadle.** (Elect. Rev. 46. pp. 83-84, Jan. 19, and 127–128, Jan. 26, 1900.)—The author gives various forms of crucible furnaces for the purpose of carrying out experiments on fused electrolysis. Simplicity of construction and the utilisation of ordinary appliances easily procurable are aimed at. The furnaces employed are heated by gas, and one also by a Swedish paraffin blow-lamp. Hints as to making good electrical connections for anode and kathode are also given. Altogether the paper contains useful hints for those engaged in this class of work. O. J. S.

1131. *Bromilow's Magnetic Separator for Workshops.* **P. Chevillard.** (Écl. Électr. 22. pp. 177–179, Feb. 3, 1900. Revue Industrielle, xxxi. p. 4, Jan. 6, 1900. Engineer, 88. p. 550, Dec. 1, 1899.)—The machine described in this paper is specially designed for the separation of particles of steel and iron from those of copper, brass, &c., in the refuse turnings and borings from engineering works. The method adopted consists in passing the mixed metal particles from a hopper into a conical shell lying with its axis horizontal. Inside are a number of electromagnets revolving on a spindle and arranged to push the contents forward in the direction of the base of the cone. The magnets after passing through a certain angle are demagnetised by the current being automatically cut off, and allow the adhering iron and steel to drop off into a receiver below through a cavity in the casing. A fixed brush assists this clearing action. The non-magnetisable metals travel forward and are discharged at the end into a separate receiver.

The machine will treat 2 tons per diem. It revolves at 30 revolutions per minute and requires a current of 21 amperes and 7 volts. It weighs about 3 cwt. and requires only about 1 H.P. for revolving and supplying the current. There are drawings in section and perspective illustrating the mechanism. J. L. F. V.

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1132. *Electrolysis of Alkali-Metal Chloride Solutions.* **H. Wohlwill.** (Zeitschr. Elektrochem. 6. pp. 410–411, Feb. 1, 1900.)—Continuation of discussion referred to in Abstract No. 269 (1900).

1133. *Crystalline Structure of Metals.* **J. A. Ewing** and **W. Rosenhain.** (Roy. Soc., Phil. Trans. 193. pp. 353–375, 1899.)—See Abstract No. 1196 (1899).

1134. *Determination of Transition Temperatures.* **H. M. Dawson** and **P. Williams.** (Chem. Soc., Proc. 15. pp. 210–211, 1899.)—Paper similar to that referred to in Abstract No. 240 (1900). F. G. D.

STEAM PLANT, GAS AND OIL ENGINES.

1135. *Steam Turbines and High-Speed Navigation.* **C. A. Parsons.** (Nature, 61. pp. 424–428, March 1, 1900. Paper read before the Royal Institution, Jan. 26, 1900.)—The author traces the history of the earliest records of the steam engine down to the latest Laval steam turbine. In 1884 the first Parsons turbine engine of 10 H.P., and running at 18,000 revolutions, was made, and is now on view in the South Kensington Museum. As steam was admitted in the centre of the turbines and worked its way out over the guide blades and vanes towards either end there was no end pressure or thrust on the bearings, and the shaft was free to revolve with a minimum amount of friction. The speed of these small turbines was extremely high. In 1888 several 120 H.P. non-condensing parallel flow turbine engines were made and run at much lower speeds. In 1892 the first large radial flow condensing turbine was constructed for 200 H.P. at 4,800 revolutions, driving a 150 kw. alternator. Its consumption was 27 lbs. per kw. hr., or say 16 lbs., per I.H.P. hour. The latest turbo-alternator of 1,200 kw. with 130 lbs. steam, 10° C. superheat, gave 18·8 lbs. per kw. hour, which is equivalent to 11·9 lbs. per I.H.P. hour, and compares favourably with the best reciprocating steam engines.

The most important field for the turbo-motor is that of high-speed navigation, and the *Turbinia* was the first boat built. Great difficulty was experienced from what is known as "cavitation," on account of the extremely high speed of the shaft driving the propellers. Elaborate experiments were carried out to investigate this phenomenon, and led to the deduction that for fast speeds, wide thin blades, coarse pitch ratio, and moderate slip are best suited to prevent cavitation. The one original shaft of the *Turbinia* was now changed for three separate shafts, each carrying three propellers, one behind the other, and 32¾ knots was now reached on the measured mile and a consumption of 14½ lbs. per I.H.P. hour. A special turbine was fitted to one of the shafts for going astern. In 1898 the Admiralty ordered a 31-knot destroyer called the *Viper*. She has four independent screw shafts with two propellers on each shaft. The boilers are of the Yarrow type, with 15,000 square feet H.S. and 272 square feet G.S. The mean speed reached on the preliminary trials was 34·8 knots, the highest run being 35·5 knots with 11,000 H.P., as compared with 6,000 to 6,500 H.P. of the ordinary 30-knot destroyers. The designs for cross channel and other classes of steamers are also briefly dealt with. L. S. R.

1136. *Balanced Piston Valve.* **W. O'Brien.** (Mech. Eng. 5. pp. 256–257, Feb. 24, 1900. Paper read before the Institution of Engineers and Shipbuilders in Scotland, Jan. 23, 1900.)—A comparison is made between an engine of the usual four-crank type, having two piston-valves and two flat slide-valves for the four cylinders, and an engine fitted with cylinders of the same dimensions, having only two Clyde balanced piston-valves and two sets of valve gear for the four cylinders. The latter engine is 5 ft. 8 in. shorter over all. With the abolition of portions of the valve gearing and pipe connections the weight of the engine is considerably less. The combined high-pressure an intermediate-pressure valve has five ports; the top and bottom ports take th boiler steam into the high-pressure cylinder through straight ports at the t

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and bottom of the cylinder. The exhaust steam from this cylinder passes through the top and bottom ends of the valve into the interior of the valve, and from there it passes through the ports on each side of the middle or exhaust port into the intermediate pressure cylinder. The exhaust from the intermediate pressure cylinder passes into the middle port of the valve, then into the receiver or connecting pipe to the valve for the two low-pressure cylinders. The low-pressure piston valve has only three ports. A. S.

1137. *Corrosive and Incrusto-corrosive Waters in Steam Generators.* **H. de la Coux.** (Écl. Électr. 22. pp. 98–99, Jan. 20, 1900, from Génie Civil, 36. pp. 117, 139, 140, Dec. 23 and 30, 1899, and Jan. 6, 1900.)—Three articles in which the corrosive effects of various substances contained in solution in water are examined, and methods of counteracting them are indicated. Some remedies proposed as preventives of the formation of incrustations have also an anti-corrosive action in the case of waters depositing incrustations which by decomposition become corrosive agents. The author denominates these "incrusto-corrosive" waters. There are also cases in which the remedies proposed against incrustation themselves promote corrosion in boilers using water which deposits innocuous incrustations.

1. Amongst corrosive agents the following are dealt with: HCl and chlorides of magnesium, ammonium, calcium, and sodium; sulphuric acid and sulphates of aluminium and copper; with some general remarks about nitrates, sulphides, sulphurous acid, and H_2S.

2. As remedies against corrosion, notice is taken of the following: Zinc, lime, calcic carbonate, soda, potash, alkaline carbonates, baric hydrate, and carbonate.

The author made special experiments with other substances, such as salts of lead, alkaline phosphates, silicates, and borates to ascertain the range of their action in boilers.

3. The substances proposed as preventers of incrustation are many, some of them being found amongst those named as anti-corrosive agents—these being thus able to perform double functions. The great matter is to select the reagent best suited to the kind of water used. Magnesia, however, should not be thus employed, because of its forming corrosive compounds with carbonate, sulphate, and chloride of calcium.

4. The author concludes that the remedies selected should act equally as regards corrosion and incrustation, not suppressing one action at the cost of favouring the other. For instance, with lime purification can be attained only by an increase of the mass of incrustation; whilst by using magnesia an increase of corrosion may be produced and even a transformation from incrusting to corroding power.

Alkaline carbonates and oxide of barium act perfectly as correctives of incrusto-corrosive waters, because they operate efficiently against both tendencies in the water. F. J. R.

1138. *Dust Destructors and Electric Supply.* **Lauriol.** (Soc. Int. Élect., Bull. 16. pp. 468–484, 1899.)—A detailed estimate of the economy in an electric supply station by the use of dust destructors as a source of energy. The results are worked out for three calorific values of refuse, viz., for 50 kw. hours per ton as in the case of London refuse, for 20 kw. hours as determined in Paris, and for 5 kw. hours, a minimum value. Four conditions of running are considered: (1) When the refuse is burnt and the power supplied

2s., 9d., and 2d. per ton respectively for the three classes of refuse. (2) When the refuse is burnt uniformly and the peak of the load taken by coal firing there results a saving of 0·1d. to 11d. per ton of refuse. (3) When the refuse is burnt as required to supply the load, unless the load factor is very high, the heavy outlay in destructor furnaces required to take the peak results in a loss as compared with coal firing. (4) When accumulators are employed to make the load factor of the plant 100 per cent. a saving of from 1d. to 2s. per ton of refuse is possible. L. B.

1139. *Gradual Variable Speed Gear.* (Engineer, 89. p. 211, Feb. 23, 1900.) —This article describes the general arrangement of a light motor vehicle fitted by Lucas (the inventor) with his expanding pulley gearing. The gear consists of two pulleys, one on the driving and one on the driven shaft, which are constructed with a lattice-work ring of steel strips, lazy-tongs fashion, in such a way that they tend automatically to expand by virtue of a toggle system, actuated by springs. Between the two shafts is a drum, which is connected with both pulleys by means of two belts. The drum is mounted in bearings upon a sliding block. By the action of moving this block towards either one or other of the shafts the one pulley is permitted to expand and the other is compelled to contract. A. G. N.

1140. *Motor Vehicles for Municipal Purposes.* (Automotor Journal, 4. pp. 279–280, March, 1900.)—This is a report giving some of the results of the trials of heavy motor vehicles carried out by the Liverpool branch of the Automobile Club. The report had been prepared by the surveyor for the Chelsea vestry, Mr. T. W. E. Higgens, with a view to the employment of motor dust-collecting vans and for street watering. This report, and one previously written by the same author, shows that although these vehicles cost on an average about £650 each, the work can be performed by them at a lower cost and more quickly than by horses, and the streets kept much cleaner. W. W. B.

1141. *Mees Motor Vehicle.* (Automotor Journal, 4. pp. 267–278, March, 1900.)—The main features of this vehicle are a motor, having two pistons in one cylinder, with pistons moving in opposite directions and connected to cranks at 180° through rocking levers; the engine is enclosed and self-lubricating, and has but one set of valves. On the end of the crank-shaft, which is placed longitudinally in the car, is a bevel pinion always in gear with a pair of bevel wheels, which give a forward or backward motion to the chain pinion shaft by means of two pairs of clutch band brakes, which fix or set at liberty alternatively the one or other of two forward speeds and one speed backwards. The whole of the gear is always in mesh, but the relative velocities of the wheels and pinions that are running idle are not great. The motor is in part air-cooled, water-cooling being adopted for the combustion space. The carburettor is of the surface type, and is placed within the spirit tank. The water is cooled by a group of radiator tubes under the front part of the vehicle. W. W. B.

1142. *Air-cooled Motors.* (Automotor Journal, 4. p. 260, March, 1900.)—This gives the results of certain brake-power tests of a small air-cooled motor, like those used on motor tricycles. The speed of the motor during the tests ranged from 2,090 to 1,710 r.p.m., and a feeble air-blast was allowed to play upon the cylinder. The tests each lasted ten minutes, and in each case the

brake power fell in that time from 2·38 to 2·01 and from 2.28 to 1·65 B.H.P. respectively. In the first case the loss in power in ten minutes was 14 per cent., and in the second case 27 per cent., showing the necessity for better cooling. W. W. B.

1143. *Molas Lamielle and Tessier Compressed Air Delivery Wagon Motor.* **P. Guédon.** (Automotor Journal, 4. pp. 238–239, Feb., 255-257, March, 1900. From "La Locomotion Automobile.")—After a brief description of previous work, this article explains the main features of an air-engine propelled vehicle, in which it is claimed that by using batteries of thin tubes the inventors are able to carry air at a pressure of 290 atmospheres with a weight of vessel of 4·5 times the weight of air. The air reservoirs are divided into two groups—one of six, the other of eleven—containing together about 500 litres, or at the pressure named 178 kilogrammes, the reservoirs weighing altogether 775 kilogrammes. On its way to the motor the air passes through a steel-coil tube 7 mm. in diameter, 8·5 mm. thick, and 6 metres in length, heated by a mineral spirit burner, raising its temperature to about 150° C. by the consumption of about 500 grammes, or 1·1 lb. of spirit. The air next passes through a pressure regulator reducing valve, on leaving which it has to be again heated by means of a coil similar to the first. The motor has four single-acting cylinders in two pairs, with pistons connected to cranks at 180°, the cranks of one pair being placed at 90° to those of the other. The pistons are fitted with cup leathers, and the exhaust valves are of the mushroom type, the admission valves being small rods with conical ends sitting in coned seats. The valves are worked by a rocking lever at the back of the engine, which receives its motion from cam-operated slotted links, one for giving full movement to the valves and the other for varying the point of cut-off. This arrangement is illustrated. The outlines of results of trials, dated October 2, give weight of vehicle empty as 360 kgs.; load carried, 10 persons; distance traversed, 8 km. = 4·96 miles; time occupied, 1 hour 20 minutes; average speed, 6 km., or 3·72 miles per hour; pressure of air at starting, 136 kgs.; at end of journey, 55 kgs.; fall in pressure, 81 kgs., corresponding to a weight of 48 kgs. of compressed air, or 6 kgs. per km., or per ton km. 1·3 kgs. The cost of air compression is not given. W. W. B.

1144. *Longuemare Carburettor* (*Heavy Oil*). (Automotor Journal, 4. pp. 260–261, March, 1900.)—This article describes a modification of the Longuemare mineral spirit air carburettor intended for carburation of air by means of ordinary kerosene, or for the evaporation of this oil. Oil is drawn by the movement of the engine piston from the float-regulated feed vessel through a notched mushroom valve form of jet-piece; the fine jets thus produced are carried by the entering air, and are baffled by a perforated plate above the jet-piece, both of which move or may move with every suction stroke of the engine. The body of the carburettor is surrounded by a jacket, which receives the hot exhaust, and descending into the space through which the mixed air and oil vapour passes on its way to the engine is a number of wings heated from the same source. Fluctuation of exhaust thus causes fluctuation of carburettor temperature. W. W. B.

1145. *Oliverson-Killingbeck Variable-speed Gear.* (Indus. and Iron, 28. p. [illegible], Feb. 16, 1900.)—Variable speed is obtained by the side grip of a belt

running between two pairs of slightly coned discs, each pair of which may at will be separated or made to approach each other, the alteration in their distance apart being made so that the surfaces upon which the belt runs are increased and decreased simultaneously. W. W. B.

REFERENCES.

1146. *Economical Generation of Steam Power.* **B. A. Tapp.** (Elect. Engin. 25. pp. 21–23, Jan. 5; 51–53. Jan. 12; 85–87, Jan. 19; 120–122, Jan. 26; 164–166, Feb. 2; and 190–192, Feb. 9, 1900.)—A series of articles on boilers, mechanical stokers, heaters, refuse destructors, &c., giving figures showing the efficiency of the various devices.

1147. *Economy of Economisers.* **A. D. Adams.** (Cassier, 17. pp. 378–382, March, 1900.)

1148. *Oil and Water Separators.* (Amer. Electn. 12. pp. 47–48, Jan., 1900.)

1149. *Feed-Water Heaters.* **G. Halliday.** (Feilden, 2. pp. 149–158, Feb., 1900.)—A description of some types of the above, including heaters by Royle, Weir, Caird and Rayner, Pimbley, &c. Some figures are also given showing the economy of the various devices.

1150. *Radiographic Examination of Coal.* **F. Kotte.** (Eng. Mag. 18. p. 611, Jan., 1900.)—An abstract of a paper that originally appeared in "Stahl und Eisen." The Röntgen rays have been applied to the detection of the presence of slate, pyrites, and other impurities in coal. The latest work has been done by Couriot at the Ecole Centrale at Paris, and some radiographs are reproduced in the original paper that were obtained by Kotte and Aulich.

1151. *Automobile Construction.* **W. W. Beaumont.** (Eng. Mag. 18. pp. 523–529, Jan., 1900.)—A short and general statement of the various developments which have lately taken place in the construction of automobiles.

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GENERAL ELECTRICAL ENGINEERING.

1152. *A Dry Accumulator.* **R. Kieseritzky.** (Elekt. Runds. 17. pp. 90–91, Feb. 1, 1900.)—A new material is described for filling accumulators which is said to surpass all previous attempts in the same direction, and for which it is claimed that it renders accumulators of all sizes as convenient to manipulate as dry cells without loss of capacity. At the same time it completely wedges in the plates rendering buckling and any falling out of the active material impossible. No information is given as to the nature of the material employed, and details as to weight of cells per watt or ampere hour of capacity are wanting. The invention is said to have been successfully employed on the tramway between Berlin and Charlottenburg for about two years. R. N. L.

1153. *Glass Insulators.* **Quantin.** (Écl. Électr. 22. pp. 389–390, March 10, 1900. Bulletin des Usines Électriques, No. 24, p. 388, 1899.)—The objections to the use of glass, namely "flying" and attracting water, have been overcome by special annealing and avoiding alkaline constituents. The difficulty of casting produced by the latter precaution has been overcome. Results of laboratory tests are tabulated, showing that in dry and wet weather the glass is from two to ten times better than similar porcelain samples. Under high tension at 7,000 volts no brush discharge occurred with the glass, whereas it did with porcelain, which at 14,000 volts broke down. The glass did not fail at this voltage. M. O'G.

1154. *Substitute for Indiarubber.* **H. L. Terry.** (Electrician, 44. pp. 326–327, Dec. 29, 1899.)—The objections to rubber for deep-sea cables are its porosity and the fact that it is put on in a jointed condition. Substitutes have not the tensile strength or resilience of rubber. Resinous bodies favour less the diffusion of liquids and gases than indiarubber, hence the superiority of guttapercha for submarine work. Admixture of rubber with bodies made from rape oil by the action of sulphur renders these bodies sufficiently soluble in naphtha to make a varnish. In this way rubber adds to their utility. Although water is objectionable in cable rubbers, several per cent. of water as shown by the chemical test may be present without detriment. M. O'G.

1155. *Indiarubber for Cables.* **O. Schaefer.** (Electrician, 44. pp. 426–427, Jan. 19, 1900.)—When applied in the "longitudinal" machine the join effected by vulcanisation is indistinguishable. Only poor rubbers heavily loaded can be extruded through the "die" machines. Where there is damp in the iron cable conduits, &c., all rubber should be lead-covered. The author thinks rubber will be largely used for high tension transmission. M. O'G.

1156. *Automatic Pressure Regulator.* **E. Dick.** (Elektrotechn. Ztschr. 21. pp. 80–83, Jan. 25, 1900.)—This regulator comprises a solenoid with a longitudinally guided core having at its upper end a rack which gears with a pinion on a shaft having an adjustable weighted arm. The lower end of the core extends into a chamber formed by a series of iron rings insulated from each other by micanite rings and containing mercury. The iron rings are

of coal vaults, sufficient coal should be accommodated to supply the boilers for at least three weeks or a month, the greater the amount of coal storage capacity the better.

Boiler-house. A convenient arrangement is for the boiler-house, where practicable, to run parallel with the coal bunkers, also with the engine-house. It is usual to sink the level of the boiler-house floor some 8 to 10 feet below that of the engine-house, so that the steam-pipe from the crown of the boilers may be conveniently placed with regard to the engine, also so that coals may be shot down from the ground level into the coal bunkers beneath. A space of 16 to 18 feet at least should be left between the boiler and wall opposite fire-door for convenience of stoking and other considerations. Good ventilation and illumination are of importance. Spaces should be provided for all boiler-house accessories and also for stoker's mess-room, with cooking range, &c.

Chimneys and Flues. In selecting position of shafts future extensions must be borne in mind. It is best to place it in the centre of the range of boilers, with the horizontal flue running right and left thereof, so that boilers may be added as the works grow.

It is however advisable, where funds and space permit, to have two shafts of smaller capacity rather than one shaft of larger capacity, so that in event of repairs being necessitated through damage, one may be shut down whilst the other is working. The area of the shafts should also be amply large enough to provide for all future boilers that may be required, and it is advisable to carry up the shafts at least 150 to 200 feet, so as to distribute the products of combustion at as high a level as possible. The usual form of chimney chosen for electrical stations is an octagonal form of unequal sides, or rather a square chimney with the corners cut off ; there is, however, a diversity of opinion as to the best form. Particulars are given as to the correct sectional area to adopt both for the chimney and the flues, and also as to foundations and construction concerning the former. In most electrical generating shafts the exhaust steam-pipe is carried up the centre of the shaft, and as this pipe and the heated column of steam inside forms the readiest path for a flash of lightning, it must be carefully earthed and connected up to the lightning conductor.

Engine-house. It is essential not only for the personal comfort of the staff, but also for the plant, that the temperature should not be too high. The author has found that a good flooring consists of unglazed red tiling, although this has the objection of not being a good insulating material. Reference is made to methods adopted in the engine foundations to prevent transmission of vibration.

That adopted at the Chelsea station, which has proved very satisfactory, is to first construct a foundation of concrete 9 inches deep ; on this sheet lead is placed, then two layers of continuous matting similar to an ordinary door-mat but very much thinner ; on this lead sheeting is again laid, and on these insulating layers the concrete superstructure of the engine bed, about 7 feet deep, is erected.

Particulars are also given concerning the workshops, stores, metre and testing-rooms, engineer's apartments and offices. It is advised that accommodation should be provided on the roof, in some convenient and accessible position, for water tanks, as a large storage of water is essential, so that in the event of burst mains or other cause preventing supply, no inconvenience is occasioned.

Finally, it is advised that a system of fire hydrants should be fitted

throughout the building. All walls (at any rate, those of the engine-house) should be carried down to same level as foundations in engine beds, and a clear space should be left all round the building between external walls and those of adjoining buildings, to prevent transmission of any vibration.

L. J. S.

1162. *Electrical Lifts and Cranes.* F. **Niethammer.** (Elektrotechn. Ztschr. 21. pp. 33–38, Jan. 11, 55–60, Jan. 18, 1900.)—In this paper the author first describes graphical methods of determining the acceleration, time of a complete lift, and other quantities, from the curves giving the relation between the torque and the speed, the speed and the time, and the current and the time. Methods are also given for comparing the relative efficiencies of different motors for particular work. The question of the most suitable generator and motor is then discussed, together with the best arrangement of resistances and controlling apparatus. A number of examples of brakes and reversing mechanisms are described, together with the counter-balance systems of Sprague and Fuller-Fraser. Several examples of travelling-cranes for workshop and dock use are then described with reference to working drawings.

C. K. F.

1163. *Storage and Transfer of Energy by Calcium Carbide.* E. **Neuberg.** (Elektrotechn. Ztschr. 21. pp. 172–174, March 1, 1900.)—The author compares the change of the kinetic energy of a waterfall into the chemical energy of calcium carbide, to that occurring when a secondary cell is charged from a similar source of electrical current. The calculations made by the author in the course of his paper are based upon the charges for current made by the Berlin "Elektricitäts Werke," which are equivalent to 18·5 pfg. per 1,000 kg. cal. when used for motor purposes, and to 63·6 pfg. per 1,000 kg. cal. when used for lighting. Taking carbide at 35 M. per 100 kg., the same amount of energy from this source will cost 16·65 pfg. Using these costs data, the author calculates the following ratios for the various purposes to which electricity and acetylene gas may be applied :—

Lighting, per c.p. hr.	Electricity, 0·151 pfg. ...	Acetylene, 0·120 pfg.
Heating, 1350 g. water heated 30–92° C.	„ 1·88 „ ...	„ 2·74 „
Motors, per H.P. hr.	„ 14·55 „ ...	„ 35·1 „

The author sums up by stating that the thermochemical data show calcium-carbide to be more satisfactory than electricity as a carrier of energy ; but because electrical apparatus and machinery is of high efficiency calcium carbide cannot compete with electricity except for lighting purposes.

J. B. C. K.

1164. *Lift Gear.* (Elect. Engin. 25. pp. 8–9, Jan. 5, 1900.)—In a new lift devised by the Electric Construction Co. there are two driving drums, revolving in opposite directions, and the ropes supporting the cage pass over one and under the other drum, thereby preventing slip. The drums are driven by right- and left-handed worms, whose thrusts counter-balance one another. The motor is connected to the worm shaft by a claw coupling having 90° play. If the load tends to drive the motor, a resistance in the field is short-circuited by the motion of a disc along a screwed portion of the shaft when the claw turns through its 90° play. Should the supply mains be incapable of

taking the current thus generated, a powerful friction brake, normally held off by a shunt-coil, comes into operation. The motor is started up through a resistance, the cutting out of which is not under the control of the driver, but is performed by a switch-bar diven by an oscillating lever from an eccentric on the motor shaft. This lever carries a pawl actuated by a magnet, which, when all the resistance is cut out, is short-circuited, thereby keeping the pawl out of action. The switch-bar is retained by a band-brake operated by a magnet, and when the circuit is broken it returns to the "all-resistance-in" position, while at the same time the motor is short-circuited upon itself through a fixed resistance, and the friction brake is applied. E. H. C.-H.

REFERENCES.

1165. *Electricity in Mining and Handling of Bituminous Coal.* (Amer. Electn. 11. pp. 299–300, 1899.)—Describes the latest forms of mining locomotive, coal-cutting machines, and electric rotary drills used for mining soft coals, built by the Jeffrey Manufacturing Company, of Columbus, Ohio. The article is illustrated, but no technical information is given. Ll. B. A.

1166. *Comparative Advantages of Electricity, Steam, and Compressed Air for Mining Purposes.* **W. E. Garforth.** (Inst. Civ. Engin., Proc. 138. pp. 436–439, 1899; also Engineer 87. p. 641.)

1167. *Applications of Electricity to Cranes and Hoists at Cripple Creek, Colorado.* (Elect. Rev. 45. pp. 847–848, Nov. 24, 1899; also Engineering and Mining Journal.)

1168. *Seasoning of Wood by Electricity.* **J. A. Montpellier.** (Electricien, 18. pp. 237–239; pp. 255–258, 1899.) Illustrated description of the method of Nodon and Bretonneau. — (pp. 273-276) Applications of wood so seasoned, and also particulars of preparation of wood for special purposes, non-inflammable, extra durability, colouring, and the removal of bark.—(pp. 304–306, Nov. 4) Works at Aubervilliers.—(p. 314, Nov. 11) Description of vats and heating stoves.—(pp. 333–335, Nov. 18, 1899) Costs and general advantages of process.

1169. *Traction Accumulators.* **J. Reyval.** (Écl. Électr. 20. pp. 94–98, 124–126, and 336–337, 1899.)—Description of cells. Remarkable details of a test on a Plante type of battery made by Ranun de Souza. M. O'G.

1170. *Interior Alternating Current Wiring.* **R. W. Lohmann.** (Elect. World and Engineer, 34. pp. 612–614, 1899.)—This paper contains instructions for wiremen to determine the impedance drop in an alternating current circuit of known ohmic resistance, the wires of which are at a given distance apart and which carry a known current of given frequency. The instructions refer to the tables given by A. E. Kennelly in the Transactions of the American Institute of Electrical Engineers, vol. x.

An elementary explanation of the "skin effect" is also given. W. G. R.

1171. *Cost of Central Station Plant.* (Elect. Rev. 45. pp. 787–788, Nov. 17, 866–867, Nov. 24, and 946–947, Dec. 8, 1899.)

1172. *Electricity in Hat Manufacture.* (West. Electn. 25. pp. 89–90, 1899.)—An illustrated description of the application of electric heat and power to the manufacture of hats.

1173. *Electricity in Japan.* (Elect. World and Engineer, 34. pp. 849–850, Dec. 2, 1899.)—An article dealing with the progress of telephony, telegraphy, electric lighting and general electrical engineering in Japan.

GENERATORS, MOTORS, AND TRANSFORMERS.

1174. *Three-Wire Distribution from a Single Dynamo.* **E. Bretch.** (Elect. World and Engineer, 35. pp. 58–59, Jan. 13, 1900.)—In order to operate a direct-current three-wire system from a single dynamo, the middle wire must be connected to the armature winding in some manner. This connection may be made at one or more points symmetrically disposed by means of slip-rings. In order to avoid alternating currents through these slip-rings, their connections are carried, before joining the middle wire, through choking-coils, whose self-induction does not affect the balancing direct-current. To avoid interference with the commutation at the main brushes, the middle wire should be connected to a large number of points in the armature-winding, but for simplicity of design three are found to be sufficient. L. B.

1175. *Parallel Working of Direct-Coupled Alternators.* **W. L. R. Emmet.** (Elect. World and Engineer, 35. pp. 95–96, Jan. 20, 1900.)—A description is given of a dash-pot used to control the action of an engine governor. The dash-pot is so designed as to be very sluggish for brief intermittent alterations in speed, though yielding freely to any continued change, such as would be produced by a change of load. The main piston of the dash-pot has first to move a small subsidiary piston, which then opens a passage allowing free motion of the oil filling the pot. Governors controlled by such means appear to give satisfactory results in practice. W. H. E.

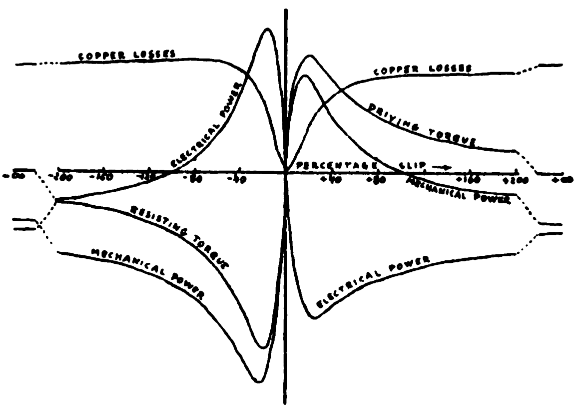
1176. *Parallel Working of Direct-Coupled Alternators.* **F. G. Sykes.** (Elect. World and Engineer, 35. p. 177, Feb. 3, 1900.)—In working two large sets in parallel (25-cycle, three-phase, slow speed, with heavy fly-wheels) it was found that the load could not be changed from one to the other, as the cross-current became excessive. The difficulty has been removed by using a more viscous oil in the governor dash-pots, and at the same time arranging that the engine speed should be controlled by the switchboard attendant. The latter condition is secured by using an electric motor to act on the governor, the motor being controlled from the switchboard. This speed control is found to be very useful in throwing the sets into parallel, and is further employed in changing the load from one set to the other; while the cross-current is eliminated by suitable regulation of the field excitation of the two alternators. W. H. E.

1177. *Tests of Multiphase Alternators for the Cusset Generating Station.* **J. L. Routin.** (Écl. Électr. 21. pp. 441–451, Dec. 23, 1899.)—The tests were made by the Behn-Eschenburg method, in which the power of the driving motor need not be more than 10 or 20 per cent. of the output of the alternator. By a simple graphical construction this method permits the determination of the voltage at the alternator terminals running on an inductive circuit as a function of the exciting current. The article is well illustrated, and there are sixteen tables giving results of tests. E. K. S.

1178. *Design of Monophase and Polyphase Generators.* **B. A. Behrend.** (Elect. World and Engineer, 35. pp. 90–92, Jan. 20; 125–127, Jan. 27, and 166–

168, Feb. 3, 1900.)—The author discusses the various points affecting the design of alternators, and condemns inductor alternators as unsatisfactory on account of the high leakage of lines between field and armature. The question of frequency is one which also should be considered when designing an alternator, as some machines work better than others at a particular frequency. The best frequency for a given machine depends upon the dimensions of the pole-pieces. W. G. R.

1179. *Theory of Induction Motors.* **J. Heubach.** (Elektrotechn. Ztschr. 21. pp. 73–78, Jan. 25, and pp. 97–101, Feb. 1, 1900.)—In a former communication (see 1899, Abstract No. 1976) the author considered the application of the Heyland diagram to the study of induction motors under normal conditions of working. In the present paper, the results then arrived at are extended to include slips ranging from $-\infty$ to $+\infty$. As the author points out, it may happen that under ordinary conditions of working a motor is made to run with a negative slip, or with one exceeding 100 per cent. Such cases may arise in the working of cranes which have accidentally been overloaded, or in

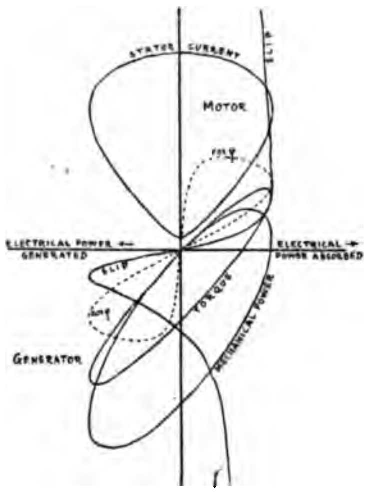


the case of tramcars running down an incline. Making use of the Heyland diagram, and then plotting the results in rectangular co-ordinates, the author arrives at the set of curves given below, which show how the various quantities involved vary as the slip changes from $-\infty$ to $+\infty$. The second part of the paper deals with single-phase motors, the single-phase motor being supposed to be replaced by an equivalent pair of polyphase motors. Curves similar to the above are given for the single-phase motor. In the concluding portion of the paper, the author explains how the Heyland diagram must be modified so as to include the hysteresis and eddy-current losses. A. H.

1180. *Rotary Converters.* **J. Herrmann.** (Elektrotechn. Ztschr. 21. pp. 60–61, Jan. 18, 1900.)—The rotary converters employed in practice in spite of recent improvements are still at least as expensive in manufacture as direct current generators. The object of the separately excited magnetic system is not to generate an E.M.F. in the winding as in the dynamo, but merely to keep the armature rotating in phase with the alternating E.M.F. If the armature were driven by a separate synchronous motor the field poles might be replaced by a simple iron ring, though this would involve the loss of the regulation of power factor which is rendered possible by varying the excitation.

converters. The machine might be further simplified, first by replacing the fixed field ring by a radial extension of the armature core beyond the holes for the winding, and then by keeping the whole armature fixed and rotating the brushes. Such a machine made at the Stuttgart Technical Institute is described. The arrangement of Hutin and Leblanc is derived from this by connecting the winding of the fixed armature by means of slip rings to the bars of a rotating commutator. The armature can also combine the function of a static transformer if provided with two windings, and can then be used either as a converter or as a polyphase transformer. L. B.

1181. *Theory of Induction Motors.* **Heyland.** (Elektrotechn. Ztschr. 21. p. 146, Feb. 15, 1900.)—Referring to Heubach's article on this subject (see Abstract 1179), the writer points out that the results obtained by him may be graphically exhibited in a much more striking form by plotting the



various quantities involved, not as functions of the slip (see curves of Abstract 1179), but as functions of the electrical power supplied to, or developed by, the motor. The diagram here reproduced shows the elegant construction which is then arrived at. A. H.

REFERENCES.

1182. *Theory of Armature Windings.* **C. Richter.** (Zeitschr. Elektrotechn., Wien, 18. pp. 8–13, Jan. 1; 32–36, Jan. 14; and 67–75, Feb. 4, 1900.)—An elaborate discussion of the conditions which must be fulfilled in various cases in order to render a closed winding possible. A. H.

1183. *Commutation in Dynamos.* (Elect. Rev. 46. pp. 43–45, Jan. 12; 86–87, Jan. 19; 211–213, Feb. 9; and pp. 299–300, Feb. 23, 1900.)—Papers of a mathematical nature, dealing with questions of design, and recent contributions to the subject.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

1184. *Transformations of Polyphase Systems.* **C. F. Scott.** (Zeitschr. Elektrotechn., Wien, 18. pp. 13–14, Jan. 1, 1900.)—By means of a single auto-transformer, the author effects the transition from two-phase to three-phase

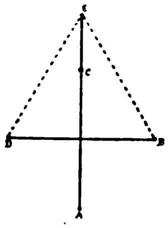


FIG 1

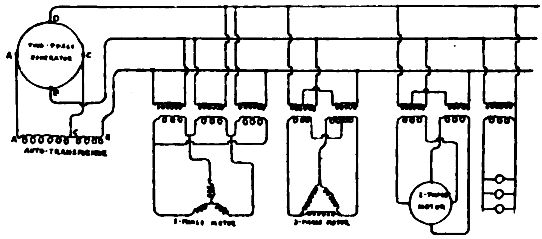


FIG 2

currents. Fig. 1 is a vector diagram of the E.M.F.'s in the two-phase generator and auto-transformer, while fig. 2 shows how such a combination may be used for distribution purposes, supplying simultaneously single-phase, two-phase and three-phase currents. A. H.

1185. *Compensation of Drop on Transmission Lines.* **E. J. Berg.** (Elect. World and Engineer, 35. pp. 60–63, Jan. 13, 1900.)—The drop in voltage over an alternate current transmission line may be neutralised by connecting across the mains at some point a condenser of sufficient capacity or an over-excited synchronous motor. The latter case is considered in detail by means of an example of a 20-mile, 1,000 kw., 60 $\sim$, 10,000 volt, 100 amp. transmission. Allowing a 10 per cent. C^2R loss, the mains have a diameter of 0·46 inch and a total resistance of 10·4 ohms. The reactance of the line,

$$pL = 2\pi \sim \times 80{\cdot}5\,(2\log_e 2s + \tfrac{1}{2})\,10^{-6},$$

where s = ratio of distance between the wires to the diameter of either. Taking 18 inches as the distance between the wires, $pL = 22{\cdot}5$ ohms and the impedance $z = \sqrt{R^2 + p^2L^2} = 24{\cdot}8$ ohms. Under these conditions the drop in the line is 13 per cent. To balance this drop, a leading wattless current of

$$\frac{EpL}{z^2} - \sqrt{\frac{E^2p^2L^2}{z^4} - C^2 - \frac{2ECR}{z^2}}$$

is required, where C is the useful current. In the above example this gives a leading current of 66 amperes. To supply this an over-excited synchronous motor of at least 660 kw. would be required running light. By making it slightly larger, a large proportion of its rated load can be taken off as power without neutralising its boosting effect. Curves are given showing the effect of placing the motor at different points of the line. The size of motor to give an over-compounding effect at the far end of the line is also calculated. If a fixed percentage drop is allowed in the line, the size of the regulating motor may be reduced and it will be called upon to supply lagging currents at light load and leading currents at full load, obtained by varying the exciting current. Calculations are given in full. L. B.

1186. *Graphical Calculations for Three-Phase Concentric Underground Mains.* **C. E. Guye.** (Écl. Électr. 22. pp. 83–87, Jan. 20, 1900.)—The author shows how to construct a geometrical figure representing the currents, voltages, and phase differences occurring in a three-phase concentric underground line conveying power. To simplify the problem the capacity between adjacent conductors is assumed to be concentrated at the middle of the cable, and the self-induction of the conductors is in the first instance neglected. There are three capacities considered, the two on each side of the intermediate conductor, and the third between the outer conductor and the protecting sheath. No numerical calculations are given, but the figure indicates how the cable may cause distortion from the symmetrical conditions of supply of the three-phase current. A second, and more elaborate, diagram is shown in which the modification due to self-induction in the line conductors is considered.

In view of the fact that the capacity of the cable is distributed along its entire length, and also because actual alternating currents are not purely sinuous, but possess harmonics of higher frequencies, the author points out that no figure can be precise for practical cases. The important question which has to be decided in actual cases is whether the perturbations caused by the cable are of appreciable magnitude. This can generally be done by neglecting the effect of the line resistance and inductance. The diagram under these circumstances is much simpler, and renders it easy to calculate the order of magnitude of these perturbations. W. E. S.

1187. *Electric Equipment of a Printing Establishment.* **G. A. Damon.** (Amer. Electn. 12. pp. 67–69, Feb., 1900.)—An illustrated description of the equipment of the "St. Louis Republic" Newspaper Offices for both power and lighting. Power is taken from the mains of the local electric light company, which supplies direct current over a three-wire system at 470 volts across the outers, with the neutral grounded. The current passes into the building through a switchboard provided with a separate switch for each of the nine circuits which supply the different classes of service. From the switchboard each circuit on its way to its respective part of the building passes through two Thomson wattmeters in series—one wattmeter for the supply company and the other for the customers, each acting as a check upon the other. These wattmeters in *each* circuit furnish a ready means of checking the cost of power used by each department, and of suggesting measures for obtaining greater economy.

In connection with the motor equipment the application and the speed control of the press motors was the most serious problem. The printing of the paper requires three Hoe quadruple presses, each capable of printing 24,000 papers per hour. The main driving shaft of each press turns 200 times a minute, and is driven by gearing from a 40-H.P. four-pole motor running at 700 r.p.m. The method of speed control adopted is the combination of armature resistance, field regulation, and the "teaser" system as developed by the Crocker-Wheeler Company. In operating newspaper presses it is essential to provide five or six *very slow* speeds to be used in adjusting the presses and in threading through the paper while "making ready" to run an edition. In doing this work the press attendants become familiar with certain speeds, and any variation not only hinders them in their work, but is also liable to prove dangerous to the hands, who are trained to certain motions. The slow speeds must therefore be constant, and they are secured by the use of a "teaser," or small motor generator, running at constant speed, the motor end taking its current from the 470-volt mains, while

the generator end delivers current to the press motor at a potential varying between zero and 80 volts. In this way a range of very low constant speeds is obtained, the higher speeds being obtained by throwing the press motor direct on to the 470-volt mains through a resistance. Normal full speed is attained when this resistance is cut out, and speeds above normal are obtained by slightly weakening the field strength of the press motor itself. The controller is provided with a solenoid magnet circuit breaker, which opens the circuit automatically in case the line voltage fails. This circuit breaker can also be operated from any one of six push buttons distributed at convenient points about the press frame. A band-brake actuated by means of a spring, and controlled by a solenoid magnet in series with the main circuit is provided, which applies itself instantaneously to gradually stop the press in case the line circuit fails, or any one of the stop buttons is pushed in an emergency.

Descriptions are given of the various other applications of the motors to the 20 Linotype machines, ¼-H.P. motor to each; Matrix rolling machine, 2½-H.P. compound wound motor; Tail-cutting machine, 4-H.P. motor; Shaving machine, 4-H.P. motor; Carriers for presses, three 1-H.P. motors; Blower for the pneumatic tube, 5 H.P. motor. Besides these there are motors for the freight lifts, passenger elevators, &c., and in the art department a ½-H.P. motor to operate the rocking device of the acid bath; ½-H.P motor belted to the rotor; and a 2½-H.P. motor belted to the saw and trimmer. The composing-room and the stereotype-room are also equipped with a motor-driven saw and trimmer similar to the one in the art department.

The indirect advantages of electrical operation were well demonstrated in this plant; for example, in arranging the equipment, the placing of the separate machines was not determined by the position of a line shaft, and full advantage was taken of this fact. Again, in planning the stereotype room the machines were not placed at right angles, as is usually the case, but were set in positions which would reduce the number of steps and motions of the workmen to a minimum. The building is fireproof throughout, and in arranging the rooms the architect was not handicapped by the necessity of providing shaft pits or belt ducts, with the consequent dangerous openings through walls and floors. The evenness of the power obtained from the press motors, the wide range of available speeds, and the convenient method of control, have proved most beneficial. E. K. S.

1188. *City Road and Wandsworth Supply Stations of London.* (Elect. Engin. 25. pp. 258–266, Feb. 23, and 294–303, March 2, 1900.)—The two stations of the County of London and Brush Provincial Company at City Road and Wandsworth are described in detail. The former was opened in 1897. The system originally employed was a single-phase 100 $\sim$ for light, and 530-volt continuous current for power. In making extensions in 1899 a two-phase 50 $\sim$ system was employed, the ultimate intention being to replace the single-phase plant altogether. The single-phase plant consists of six 180-kw. Mordey alternators and Brush engines, the two-phase of six 200-kw. E.C.C. alternators and Brush engines. The direct current is supplied by two 550-kw. General Electric dynamos and Allis engines. A battery and transformers are employed, allowing all three systems to be supplied from any single generating set at periods of light load. At the Wandsworth station the plant consists of six 2,000-volt 100 $\sim$ 180-kw. Mordey alternators, driven by Raworth Universal engines. Three of the feeders from this station are

thirteen miles long, and for these the pressure is transformed up to 6,000 volts. As in the City Road station, it is intended here also to change over to a 50 ∼ two-phase system ultimately. Babcock boilers, Green's economisers, and Ferranti switchboards are employed at both stations. Details are given of the distributing network, also illustrations of the plant and load curves taken under various conditions. L. B.

1189. *Tests of Steam Alternators at Zurich.* **H. Wagner.** (Elektrotechn. Ztschr. 21. pp. 147–151, Feb. 22, 1900.)—A detailed account is given of tests of the boilers, engines, and alternators recently installed at the central station supplying the town. The boilers, seven in number, were made by Escher, Wyss & Co., and are of a composite type. Each consists of a lower boiler of the Lancashire type, connected with an upper boiler which is multitubular (fire-tubes). The lower shell measures 16 ft. 5 in. by 7 ft. 9 in., and the upper 12 ft. 10 in. by 7 ft. 2 in. The latter has 106 wrought-iron welded tubes (3¾ inches), and is fitted with a steam dome. Two tubes connect the boilers, the one to take steam to the upper boiler from the lower, and the other to supply water to the lower from the upper. The lower boiler can also be fed direct. A Schwörer superheater is fitted in the flue between the two boilers. The grate area is 35 square feet, and the heating surface 1,940 square feet. The fuel used is coke, and the working pressure 125 lbs. per square inch. Some of the results of the trials are appended :—

Water evaporated per lb. (gross) of coke	15·8 lbs.
„ „ per square foot of heating surface per hour	2·0 „
Coke burned per square foot of grate area per hour	16.0 „
"Efficiency" of boiler	75·2 %

The engines are tandem compound condensing, by Sulzer, with valve regulation. They were guaranteed to give 1,160 I.H.P. and 1,000 effective H.P. with cut-off at 0·28 in the high-pressure cylinder, and 1,370 I.H.P. and 1,200 effective H.P. with cut-off at 0·40 ; with 117 lbs. steam pressure and speed 100 r.p.m. At a trial made with 1,167 I.H.P., the weight of water used per I.H.P. per hour was 13·1 lbs. The effective H.P. was taken as 1,167 — (57 + 44), 57 being the I.H.P. at no load, and 44 being allowed for additional friction at full load, viz., 4 per cent. of the load. This gives an efficiency of 91·3 per cent. In this test the friction of the alternator was included. (H.P. here used = English H.P. less 1·4 per cent.)

The alternators are three-phase machines of the Oerlikon inductor type, each being direct coupled to its engine, with the inductor acting as a flywheel. They can be used as single-phasers by putting two of the windings in series and switching out the third. The armature of the exciter is mounted on the shaft of the alternator, and in some of the tests was used to drive it in order to find the iron losses and friction, the engine being uncoupled.

Guaranteed output, with power factor = 0·85, 1,200 kilovolt-amperes ; pressure, 2,000 volts ; periodicity, 50 ; speed, 100 r.p.m. ; total weight, 40 tons ; weight of rotor, 26¼ tons ; diameter, 15 feet.

After a run of 8¼ hours with a water-resistance load of 750 kw., the greatest temperature rise was 19° C. in the armature. The exciting current required was 42 amperes at 26 volts ; for a large inductive load this has to be increased to 120 amperes. The efficiency of the set, with 750 kw. load, was 88 per cent. (ratio of effective E.H.P. to I.H.P.). Friction losses of alternator, 16 kw., or 1·6 per cent. of full load ; iron losses, 22·5 kw. Total excitation losses, 4·8 kw. With 850 amperes the calculated C^2R loss in the arma-

ture = 24 kw. (R for one limb being 0·067 ohm); by tests this loss was found to be 27 kw., including eddy losses. With a load of 940 kw. at 2,000 volts and power-factor = 0·8, the efficiency of the alternator was 98·5 per cent., including friction losses; and with a non-inductive load of 750 kw. the efficiency was 98·8 per cent.

The two alternators were switched in parallel without difficulty, with any load, and ran in parallel without a trace of hunting.

Taking the efficiency of the set as 88 per cent., the coke used per kw. hour was 2·9 lbs. In daily work on the town load the average fuel consumption for three months (September to November) has been 4·6 lbs., of which 8 per cent. was coal.

The average evaporation has been 14·6 lbs. of water per lb. of fuel, although most of the coke was unusually moist. With fairly dry coke the results are expected to be 10 per cent. better.

The paper concludes with a brief description of three 200 kw. Oerlikon motor generators, which are used for feeding part of the town tramways from a substation. Each consists of a three-phase 1,950 volt motor coupled to a four-pole 550 volt dynamo. The efficiencies of conversion at quarter, half, and full load respectively are 75, 85, and 88 per cent., the apparent efficiencies being 55, 72, and 79 per cent. W. H. E.

1190. *Chambly Transmission Plant.* **E. M. Archibald.** (Canad. Elect. News, 10. pp. 1–6, Jan., 1900.)—The transmission of electrical power from Chambly to Montreal was inaugurated in June, 1899. The Royal Electric Company has for many years been supplying the great bulk of the electric light and power service in Montreal, Canada, and has up to the present been utilising steam power for generating purposes. The company secured control of an immense water power situated at Chambly, on the Richelieu River, about fifteen miles from Montreal. It was found, after careful calculation, that the cost of water and steam power for the size of the plant necessary—8,000 H.P.—was almost equal, but that for any increase in size, the water power decreased at a much more rapid rate than did steam.

A contract was accordingly drawn up whereby the Chambly Manufacturing Company was to supply the Royal Electric Company with a specified amount of power in Montreal, with provision for increase, the steam plant remaining as at present for two years to provide for possible contingencies.

The hydraulic equipment of this plant has previously been fully described in the above journal, and this article deals solely with the electrical equipment. The generators, eight in number, were specially designed for this plant. Each is a 2,000-kw. two-phase inductor machine running at 158 r.p.m. and generating current at 12,000 volts directly at the machine at 66 cycles per second. Owing to the high voltage generated in the machine, all joints in the armature-coils are made with the greatest care. The joint after having been carefully soldered is covered with several layers of pure rubber tape, over which a composition of rubber and sulphur is placed, and covered all over with several layers of insulating tape. The joint is then soaked in boiling paraffin wax, which vulcanises the rubber, thus producing a joint such that there is no break in the complete insulation of the wire.

Such joints as these are made in connecting the armature coils together, and for all switchboard work. The base of one of these machines is a hollow rectangular casting, whose outside dimensions are 17 ft. 2 in. long by 10 ft. 11 in. wide and 25 inches thick, weighing no less than 100 tons. It is set on a concrete bed. Resting on this base is the armature, built up

[redacted]

in two parts, an upper and a lower, bolted together in the middle. This armature is 15 feet in diameter and 6 ft. 6 in. wide. The coils are all machine wound, very carefully insulated, and intersect each other, the inner curving round the outer so as to be in quadrature. The single field coil, resting on the armature in a slot specially prepared for it, has slightly smaller diameter than the armature and is wound of bare copper strip insulated with japan and insulating linen. The joints in this strip are butted together and soldered with a special solder, thus producing a joint no thicker than a copper strip.

The inductor, built of laminated iron, and weighing 80 tons, is the only revolving element in the whole construction.

The air-gap between the inductor and armature is $\frac{1}{2}$ inch. The field excitation is very small, being only $\frac{3}{4}$ of 1 per cent. of the total output of the machine. The shaft to which the spider containing the inductor is attached is 12 inches in diameter and is coupled directly to the turbines. Two exciters are provided, each of which is capable of fully exciting the complete installation.

From the alternators and exciters the cables pass through ducts in the concrete floor to the cable tunnel situated under the switchboard gallery. This cable tunnel has a vaulted roof, and is of sufficient height and width to allow free passage to several persons walking abreast. The cables, which are all lead-armoured, are placed on racks in the cable tunnel and are passed through ducts in the solid concrete to reach their respective places on the switchboard. The rubber insulation on all cables is $\frac{5}{32}$ inch thick, and they are tested to 40,000 volts. The switchboard is of marble and was tested up to 20,000 volts. The wooden framing was soaked in asbestos paint to make it fireproof and increase its insulation.

There are two sets of 'bus bars. These have a $\frac{5}{32}$ inch rubber insulation, with a thick jute outer covering. This was used instead of lead armouring on account of there being no possibility of a static charge collecting, as would be possible in the latter case.

The high-tension switches employed are of a novel type. As they appear on the switchboard there is only a small iron frame in which a long wooden lever may be turned through a 120 degree arc, and a small iron handle placed above. This latter is connected by means of a lever on the back of the switchboard to two valves, each placed in an air-duct into which air is pumped from a fan blower. These air-ducts are two wooden boxes running the entire length of the switchboard, and are situated so that when the valve is open a jet of air impinges on the contacts of the high-tension switch, thus destroying the arc. The iron handle directly above the high-tension switch cannot be opened until the valve in the air-duct is opened, thus always insuring an air-blast on the breaking contacts. Two 45-inch Sturtevant fans are employed for producing the air-blast. For the switch itself the moving lever on the face of the board is directly connected to a rocking lever, which moves a trolley to and fro containing the dead side of the switch. This trolley moves forward and engages with one set of contacts connected to the upper 'bus bars, or backwards to the lower 'bus bars, according as the lever is moved to the right or to the left of the centre. The contacts of the two sets of 'bus bars are 9 feet apart, and though the "off" position of the trolley is midway between the two, a break of 6 feet may be produced by moving the lever slightly past the centre. To prevent arcs from jumping from one switch to another they are separated by marble barriers 2 feet high. The ammeters

Air-cooled transformers are employed for reducing the voltage to 500 volts—that required by the two-phase induction motors for driving the fans. The transmission lines will eventually consist of four 4-wire two-phase cables on two separate systems of poles. No fuses or circuit-breakers are used in the line, as the generators, on account of the great inductance of their armatures, will carry a short-circuit for a short time without any injury. The transmission wires of bare copper are placed 18 inches apart, and are carried on triple petticoat porcelain insulators tested to 40,000 volts. For protection against lightning three barbed wires are earthed at every pole, one being on the top of the pole, and the other two at the outer ends of the upper cross-arm; all are mounted on glass insulators, these being used on account of the less liability to fracturing the barbed wire and thus producing a short-circuit, than when secured by ordinary staples. Lightning arresters and choke-coils are provided at four places on the line where it passes underground, as well as at the power house. At such points there are eight gaps between each line and the ground, each gap being for 2,000 volts. The line loss is about 10 per cent. at full load.

At the substation in Montreal the voltage is reduced to the city voltage of 2,800 volts by means of twenty-four 200-kw. single-phase transformers immersed in mineral oil and water cooled. Power and light are supplied from the same circuits, the slight regulation being performed by hand at the distributing board, the machines themselves having an inherent regulation of 10 per cent., between no load and full load. As each phase is independent in the two-phase system no method is needed to balance the loads on either phase, except that in order to obtain the full capacity of the machine each phase must be fully loaded. L. J. S.

1191. *Works of the King's County Electric Light Co., Brooklyn, N.Y.* (Elect. Rev. N.Y. 35. pp. 323–326, Nov. 22, 1899.)—This article deals fully with the coal-hoisting and conveying mechanism which handles the incoming fuel for the boilers; and also with the arrangement of mechanical stokers and automatic ash hoppers. The present installation of generating units comprises four sets of 1,000 H.P. each and it is intended subsequently to install two other sets each of 2,000 H.P. The dynamos, direct-coupled to horizontal cross-compound engines, are of the three-phase type with stationary armatures. They are designed to operate at 98¾ r.p.m. and to give three-phase current at 25 cycles per second and 6,000 volts. The installation includes two direct-coupled exciter units. The arrangement of the switchboard is such that the operators in the station are nowhere brought into proximity with the high-tension circuits. The high-tension apparatus is installed in a cellar, and only the handles for manipulating the switches extend up into the main engine-room, the current-carrying parts all being on the floor below.

All the energy from the central station will be transformed either to direct current by the use of synchronous converters at substations, or rectified for arc lighting, or into mechanical energy and out again as some other form of current through synchronous-motor driven dynamos. The experiment of rectifier lighting is to be undertaken on a somewhat large scale by the King's County Company.

The situation of this corporation with regard to the electric-lighting industry of Brooklyn is such that all the present generating plants and all substations now in use may become centres of distribution for central service.

The present plan for the distribution of electric current in Brooklyn is that the above-described station is to be the middle one of three along the East River and bay side of the borough of Brooklyn. The first of these stations is that at Bay Bridge, which feeds a large territory in the southern part of the borough. The new station, which is almost under the shadow of the Brooklyn Bridge, being situated a few hundred yards north of it, is intended to supply the central and populous districts of Brooklyn and Williamsburgh.

It is proposed to erect another large station at a point further north, which will supply the neighbouring districts. (See also 1899, Abstract No. 1796.)

L. J. S.

1192. *Transforming Station of the Buffalo General Electric Co.* (Amer. Electn. 12. pp. 59–67, Feb., 1900.)—The Niagara Cataract Power and Conduit Company delivers 8,000 H.P. three-phase current at 350 volts and 25 cycles per second to the central station of the Buffalo General Electric Co. This central station delivers four classes of service; namely, constant current for arc lights, 62 cycle alternating current for the incandescent lighting in the scattered districts, 500 volt direct current for motors, and 220 volt three-wire direct current for the local incandescent lighting. The station is unique in that there are no steam or hydraulic prime movers, all mechanical power being obtained from alternating current motors fed from Niagara.

The plant consists of fourteen 150-kw. induction motors driving twenty-eight 125-light arc machines; two 425-kw. induction motors driving single-phase alternating current generators, giving current at 62 cycles per second; one 425-kw. induction motor driving two direct-current generators, each 200-kw., 130 to 190 volts; two 200-kw. and two 100-kw. rotary converters; two 80-H.P. exciter sets; 150 Chloride (75 on each side) accumulator cells having a rated capacity of 3,000 amperes for a 1½-hour discharge rate.

The original apparatus for supplying the direct-current load consisted of two 100-kw. 125-volt rotary converters which were run in series with each other on their direct-current ends across the three-wire system. The machine is illustrated and attention is drawn to the fact that the commutator has practically the same length and diameter as the armature itself, this being due partly to the low voltage and also to the fact that a three-phase rotary converter can be made to deliver considerably more current without overheating than the same armature and fields would generate if mechanically driven as a dynamo.

A peculiarity of rotary converters for lighting service is the fact that the voltage of the direct current output is always exactly proportional to the alternating voltage on the collecting rings. If the latter varies due to changes of load and drop in the alternating current system the direct voltage varies with it, thus requiring as perfect regulation (so far as momentary changes of pressure are concerned) in the alternating system as is needed for the direct-current incandescent lighting. On this account and in spite of the greater cost and lower efficiency of motor generators as compared with equivalent rotaries, the additional transforming apparatus which has been installed is in the form of a motor generator in which the direct current is quite independent of the varying drop in the transmission line, and any sudden reactive drops in the transformers when alternating current motors are started. The motor generator has proved so very convenient that the Company is about to add a further unit consisting of two 400-kw. dynamos driven by a 900-kw. induction motor.

It may be mentioned that the regulation of the voltage of the rotary converters is partly effected by reactive coils, consisting of series windings on laminated iron cores, the three cores of the three phases forming mutual magnetic returns for each other. These coils introduce self-induction into the alternating current circuits, and such self-induction can be utilised by means of leading or lagging currents, to give a boosting or depressing effect upon the voltage, the leading and lagging currents being introduced by strengthening or weakening the field excitation of the machine. If the *field of the rotary is strong,* leading currents are drawn through the reactive coils and set up therein an inductive counter E.M.F. which on account of its phase relation adds to the original impressed E.M.F. If the *field of the rotary is weak,* lagging currents are drawn through the reactive coils and the inductive counter E.M.F. swings round so that it now opposes the impressed E.M.F. and so lowers the voltage. The result, so far as practical operation is concerned, is about the same as in the direct-current dynamo, *i.e.,* the field of the rotary is strengthened to increase the voltage and weakened to lower the voltage. By means of these reactive coils a range of pressure of about 12½ volts can be obtained.

The switchboard, which is fully described, is arranged for the rotaries, motor generators, and storage batteries being run in parallel. Detailed particulars are given of special swivel switches for the direct-current side of the rotaries; of a special field switch made in the hatchet form; and of the motor-driven-end-cell-regulating-switches for the Chloride accumulators.

The demand for energy throughout the twenty-four hours averages about 2,200 H.P. The battery carries the three-wire incandescent load during the evening without any help from the machines, the motor generator and the rotaries being shut down so as to reduce the load peak. During the day when the arc and incandescent load is very light the motor generator is run to carry the 220-volt load and charge the battery. As soon as the battery is charged the motor generator is shut down, the rotaries being then started up to carry the three-wire load. E. K. S.

1193. *Development of the Niagara Power System.* **J. E. Woodbridge.** (Amer. Electn. 12. pp. 1–20, Jan., 1900.)—The general design of the recently added alternators (there are now ten generating units each 5,000 H.P.) is the same as before, that is, an umbrella type of field rotating about an internal stationary armature. There are, however, some changes in detail with a view to the better dissipation of the heat, for although the machines have the extremely high efficiency of 98 per cent., the 2 per cent. wasted amounts to so much as 100 H.P. The spiders holding the two bearings are forced downwards by means of bolts into tapered seats, bored in the interior of the frame. The bearings themselves are also forced to a tight fit in the spiders, and are piped to an oil system, a screw pump lifting the oil to a reservoir placed under the eaves of the power house, from which it circulates by gravity through the bearings and down again to the pit. An oil recuperating system is provided consisting of tanks in which the oil is boiled and then filtered; the boiling is accomplished by means of electrical heaters, its purpose being to drive off any water that may become mixed with the oil.

To keep the bearings cool, holes are cored out which are connected with water-pipes. The frame has vertical ribs in which the armature laminations are dovetailed, and through these ribs run vertical passages which carry water for the purpose of cooling the armature core. Pipes connect the lower

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ends of these passages, while the upper ends are capped and connected together by means of small square cross passages cored in the casting.

The field cores are made up of bare copper strip wound edgewise, but differing somewhat from usual edgewise coils in that there are four layers. The four layers are separated from each other and rigidly held in place by means of metal spacing rods covered with mica and shellac insulation. Between these spacing rods there is ample room for the ventilation of each layer, circulation of air being permitted by means of ventilating openings in the casings. The edgewise turns of each layer are insulated from each other by strips of built-up mica and shellac insulation.

The new main turbine wheels are controlled by magnetic clutch governors designed by Coleman Sellers, in which centrifugal weights operate contacts in an oil bath, and these contacts close the circuits of electromagnetic clutches, one for the opening and the other for the closing motion of the gates. The alternators are shut down by simply opening the field circuit, the same action starting the governor into motion to shut off the water from the main wheels. Circuit-breakers in the field circuits of the machines are wired to an emergency switch, by closing which the fields of all the machines running in parallel with each other may be opened simultaneously in case of emergency, and the gates of the water-wheels of the same units may be at the same instant started towards the closed position.

A long and interesting account is given of the transmission of 15,000 H.P. to the works of the Union Carbide Co. Although the distance transmitted is only 11,000 feet it has been found worth while to step up from 2,200 volts two-phase to 11,000 volts three-phase, the transformers, six in number, being connected on the system introduced by C. F. Scott. The output of each transformer is 2,500 H.P.; they are made by the Westinghouse Co. and are oil insulated and water cooled. At the works of the Carbide Co. the voltage is reduced in two steps from 11,000 down to 110 volts, the first step by means of six units exactly similar to the step-up transformers, and the second step by means of ten 2,000 H.P. step-down transformers which have been supplied by the Wagner Co.

A number of interesting details are given of the construction of all the transformers, including those of the air-blast type supplied by the General Electric Co. Efficiency curves are given.

The heavy switching work in the Niagara power station is done by compressed air which is obtained from a water-driven Worthington pump. Most of the circuit-breakers are fitted with a time element device which has for its object to prevent a short-circuit at a point distant from the power house, opening any but the nearest circuit-breaker to it. Two methods by the Westinghouse Co. (Stillwell) and the General Electric Co. are described, as well as the *reverse current* circuit-breaker mechanism as used on the Niagara-Buffalo transmission line.

Particulars are given of a special Westinghouse 450-kw. transformer giving 37,500 amperes at 12 volts. The transformer has a single secondary turn and the pressure is regulated from 12 to 30 volts by changing the number of turns on the primary side.

On the Niagara-Buffalo transmission line the voltage is 11,000 and the wires are arranged triangularly 3 feet apart and spiralled at intervals. The maximum load at this voltage is about 10,000 H.P., so that in order to allow for the expected increase of load it is proposed to raise the line pressure to 22,000 volts besides erecting another pole line to Tonawanda.

been taken down, as the trouble they caused through falling proved greater than any probable benefits. Lightning arresters are in use at the transmitting end, and also at the Tonawanda substation and at Buffalo where the line goes underground.

The article closes with an account of the work of the Cataract Power and Conduit Co. which assumes control over the transmission line where it enters the Buffalo City limits and handles the power from that point to consumers' premises. A number of interesting particulars are given of the various underground cables and of the substations. Amongst customers for power are the Buffalo General Electric Co., 8,000 H.P.; the International Traction Co., 5,000 H.P.; a large grain elevator, 1,000 H.P.; whilst the Union Dry Dock Co. operates its extensive workshops, &c., entirely by means of induction motors, practically every machine, tool, elevator, crane, &c., having its own motor belted to it. E. K. S.

1194. *Detroit, Ann Arbor Interurban Railway.* (Street Rly. Rev. 10. pp. 5–8, Jan., 1900.)—The Detroit, Ypsilanti and Ann Arbor Electric Railway has 50 miles of track and runs 20 cars, each equipped with double trucks and four 50-H.P. motors. Each car is provided with a series of multiple controllers for operating the motors in combinations of pairs in parallel-series, or all motors in parallel. Three Westinghouse 225-kw. direct-current generators at 250 r.p.m., and 575 volts are connected by flexible couplings to 450-H.P. engines. Motor-driven boosters of 185 and 125 kw. are driven off the 'bus bars and operate in series with the feeders, whose voltage they raise to 900 volts. E. H. C.-H.

1195. *Interurban Tramways, Buffalo, N.Y.* (Street Rly. Rev. 9. pp. 815–822, 1899.)—The International Traction Company now owns almost all the lines around Buffalo and Niagara Falls. It operates the Buffalo city cars, equivalent to 5,000 E.H.P. on the average, from the 11,000-volt transmission line from Niagara, which is brought direct to five stations. At these stations a novel type of fuse is used; when the main line opens it is short-circuited through an explosive fuse provided with tubes which lead the gases away and blow out the arc. By clockwork and a battery it is so arranged that the overload must be on the station 3½ seconds before it will operate the station fuse. In three stations the 400-kw. converters are started by direct current; in the other two by a 30-kw. induction motor, with independent transformers, coupled to a 25-kw. direct-current generator. The armatures of the rotaries are given a shuttle movement by an electromagnet and an intermittent current, thereby securing uniform wear.

Cast-welded joints, to the number of 11,000, were made last year by the Lorain Steel Company. Also, around all special work, copper cables have been provided and welded in place, thus permitting easy removal for repairs without interfering with the return circuit. The operations in cast-welding are fully described. E. H. C.-H.

1196. *Detroit, Port Huron Interurban Railway.* (Street Rly. Journ. 16. pp. 119–124, Feb., 1900.)—The Rapid Railway Company of Detroit, Mich., the pioneer high-speed railway, used to run over 20 miles of track at 25 miles per hour using the direct-current system throughout. It is now about to operate a route of 78 miles to Port Huron from one main half-way power house at Baltimore. Cedar sleepers, gravel or stone ballast, 70-lb. rails, and "Crown" bonds are being used. The power house contains four 800-H.P. Babcock

and Wilcox water-tube boilers with "Roney" stokers, the draught being produced by two slow-speed, up-discharge, direct-connected steam fans, which deliver into a short stack 7 feet in diameter reaching only a few feet above the roof. There are three main engines of the Westinghouse vertical tandem type, cylinders 21½ inches and 37 inches by 22 inches stroke, giving 1,000 H.P. each at 214 r.p.m. These are connected direct to three 500-kw. Westinghouse engine-type three-phase generators, giving 750 amperes per phase at 375 volts and "3,440 alternations." To drive the alternators in parallel with fluctuating loads, the engines are provided with apparatus by which the speed of any one can be varied at will from the switchboard. There are also two steam exciters at 125 volts. All the engines exhaust into one Worthington jet "dry-air pump" condenser. Compressed air is provided for cleaning out the electrical machinery. There will be five rotary substations where the 16,500-volt current will be stepped-down and then converted by rotaries into direct current. One set of poles serves for the high-tension transmission line, the low-tension feeders, and the bracket arms for the trolley wire. "Locke" porcelain insulators are used on the high-tension lines. The new 50-feet cars each have two 75-H.P. motors. The schedule time including stops will be 27 miles per hour, with a speed of 45 miles per hour between stations. Freight traffic will be handled by Baldwin-Westinghouse electric locomotives. The electric cars take 50 per cent. of the local traffic in fruit, fish, meat, &c. (See also 1899, Abstract No. 1097.) E. H. C.-H.

1197. *Track Construction in Buffalo.* (Street Rly. Rev. 10. pp. 26–27, Jan., 1900.)—Where ordinary stone paving is used between tracks, and the same or asphalte outside, "trench" construction is used. Longitudinal trenches are dug 17 inches deep and shovel-width at the bottom, with cross trenches alternately 17 and 20 inches deep at 5-feet centres. Hard oak ties, 5 × 7 inches × 7 feet are then put in the cross trenches, the rails spiked on to them and gauged, and held temporarily by fishplates. The track is surfaced and the ties in the shallow trenches tamped with dry stone. Concrete is then run into the deeper cross trenches and into the longitudinal trenches, and after 72 hours the fishplates are removed and the joints cast-welded. Pounded sand is then laid between trenches as a base for the common stone paving. Where asphalte is used outside the rails, toothing stones are set outside them. For first-class granite sett paving, the ground is excavated 7 ft. 8 in. wide and 15 inches deep with cross trenches 5 inches deeper for the ties, which are set in concrete. After alignment, the whole is run in with concrete and covered with 4 inches of gravel to receive the setts.

E. H. C.-H.

1198. *The Electric Tramway and its Future.* J. Swinburne. (Feilden, 2. pp. 125–133, Feb., 1900.)—The most serious and obscure problem in connection with electric tramways is the earth return. The common idea that electrolysis cannot occur unless the pressure is sufficient to decompose water is erroneous. The effects of electrolysis are cumulative. Insulated return feeders give the only satisfactory solution. In order to keep the rails at zero potential it is only necessary to insure that there is the same loss in all the feeders, which can be secured by adjustable resistances in each feeder, or by auxiliary dynamos therein.

The author suggests (though he has not worked out the cost) that each car might carry an alternating motor running at a uniform speed, whether the car is at rest or in motion. This motor would be coupled to a direct-current

generator which would then drive the usual tramway motor. The system would obviate difficulties with long-distance transmission or earth return, and would permit easy speed regulation by varying the field of the generator.

The accumulator system is likely to become of more importance, as improvements in batteries decrease their dead weight. Vibration is the greatest enemy of a cell. Not only must the coating of a plate stay in place: it must also remain in electrical contact with its support. Laboratory tests are therefore of small value, because high capacity and discharge rates can be easily obtained at the expense of durability.

In the future of tramways the author considers oil or steam will play an important part. Recent developments in steam vans make it probable that steam will have another innings on tramways, especially for distances where difficulties arise in electrical transmission. One necessity for good locomotion is uniform speed: cart-horses are the chief obstructions in streets. The abolition or reduction of horses, coupled with smooth non-hammering wheels, means good smooth roads, easily kept in repair. If we have hard and smooth streets and successful automobiles, then the need for tramways, electrically worked or otherwise, is gone. England is starting electric trams ten years after other people, with the result that we have the advantage of others' experiences; but we also start with a system which is ten years nearer its death. In ten years' time the motor 'bus may have ousted the electric tramway with its capital cost and its inflexible system. E. H. C.-H.

1199. *Columbia Electric Automobiles.* (Elect. World and Engineer, 35. pp. 53–56, Jan. 13, 1900.)—This article describes the construction of the electrical vehicles manufactured by the Columbia Company, of Hartford, Conn. The special features are a flexible frame, wooden wheels, and a general lightness of design. Cars with both one and two motors, driving the rear wheels through double-reduction gearing, are described. Either solid rubber or pneumatic tyres are fitted, and it is stated that there is a useful field for both types. From 40 to 44 accumulator cells are employed for each car; these are manufactured by the Electric Storage Battery Co., of Philadelphia. The speed controls are obtained on some carriages by battery commutation alone; on others by series-multiple motor arrangements also. The vehicle equipments vary from one with a 700-lb. battery, 140-lb. motor, 8⅔ to 1 reduction gearing and motor current of 20 amperes at 75 volts, to one with a 1,390-lb. battery, 310-lb. motor, 13 to 1 reduction gearing, and motor current of 40 amperes at 75 volts. Several designs for the rear axle arrangements are described and illustrated. (See also 1900, Abstract No. 768.) A. G. N.

1200. *Goldschmidt's Rail-Welding Process.* **Goldschmidt.** (Street Rly. Journ. 16. p. 158, Feb., 1900); and **Beyer** (Street Rly. Journ. 16. pp. 158–159, Feb., 1900.)—This process permits the rapid production of molten iron in a crucible without a cupola. Powdered aluminium is mixed with powdered oxide of iron and is ignited, when the latter supplies the excess of oxygen necessary to support the combustion of aluminium, which forms liquid aluminium oxide, or "corundum," and reduces the iron oxide to molten iron. A sheet-iron mould is placed around the joint to be welded and is packed with stones and sand. The mixed powder of aluminium, &c., is ignited by a special fuse, consisting of a small ball of superoxide of barium and aluminium, which is itself ignited by burning magnesium ribbon. The aluminium oxide rises to the top of the crucible, and when poured enters the mould first, forming a thin protecting coating on the sheet iron and sides of the rail. A

layer of corundum also forms on the inside of the crucible as a fireproof glaze, which preserves the heat of the molten metal to such an extent that the workmen can handle the crucible without trouble.

Beyer added to the above description given by Dr. Goldschmidt to the Verein Deutscher Strassen und Kleinbahn Verwaltungen, some notes on the effect of temperature on cast-welded joints. He experimented on a 7-inch girder rail, having a cross-section of 52 sq. cm., and a tensile strength of 6,000 kg. per sq. cm. The modulus of elasticity which would theoretically double the length of an iron rod 1 sq. cm. in section is 2,000,000 kg. cm. Therefore for a range of 60° Celsius, which he considers the maximum in Germany, the force, considering iron to expand 0·1079 per cent. for each 100° Cels., is 67,330 kg., so that the factor of safety in this case is 4·6. He claims that the temperature of the welding may be so chosen that the ends of the rails are not actually melted, thus preventing any change in the structure of the material. E. H. C.-H.

1201. *Cost of Arc Lighting.* **H. H. Wait.** (Amer. Inst. Elect. Engin., Trans. 16. pp. 579–604, Nov., 1899.)—Tables are given in this paper showing the comparative first cost and operating expenses of various arc-lighting systems, on an equitable basis. The author refers to a recent article by W. L. Robb (see 1900, Abstract No. 955) on the Hartford system of arc lighting, where it was stated that the changes in the Hartford plant would pay for themselves in about two years. From the tables in the present article it would appear that in some cases the more modern continuous-current systems might replace older ones and pay for the changes in still less than two years. The question is so dependent on local conditions, however, that it is impossible to make any general statements.

The vital question in comparing alternating and direct-current systems is the relative amount of power consumed for the same amount of light. In compiling the tables the different types of lamps have been given the following ratings for the sake of comparison :—

Direct-current open arc—450 watts at arc	2,000 c.p.
„ „ enclosed arc—450 watts at arc ...	1,500 „
Alternate-current enclosed arc—450 watts at arc	1,150 „
„ „ enclosed arc—400 watts at arc	950 „
Direct-current open arc—300 watts at arc	1,200 „
Direct-current enclosed arc—300 watts at arc ...	900 „

To arrive at an equitable figure for comparing the direct-current open and enclosed arcs, it was assumed that the ratio of watts per mean spherical c.p. in the open arc to those in the enclosed arc is 75 per cent. This figure is practically a mean of the results obtained by Elihu Thomson, L. B. Marks, Pierron, and W. O. Steel. It was further assumed that the excess of watts per mean spherical c.p. for alternate-current over direct-current arcs is 33⅓, which is practically a mean of the results obtained by Matthews, L. B. Marks, Elihu Thomson, W. O. Steel, and the Western Electric Co. In the table of costs, the resulting costs have been divided by the nominal candle-powers so that the cost can be compared readily at any reasonable rating. The tables are all made on the assumption that the arc lighting part of the plant is running at very nearly full load whenever it does run. This will, of course, not apply to commercial lighting circuits, and considerable corrections will have to be made for such conditions.

A point in favour of the alternating systems is the fact that the position of

the plant or other local conditions may permit a saving in the line investment for example, where a large number of circuits have to be run for a long distance in the same street, a saving in the investment could probably be made by the alternating system by the use of a substation at the point of distribution. In cases where there is already a greater generator capacity installed than is actually needed, it is, of course, possible to leave out a considerable portion of the investment shown in the tables. In rare cases, the peak of the commercial lighting and power load would not overlap the arc-lighting load, and under such circumstances, some of the transformer systems, either direct or alternating current would have a great advantage.

Curves are given in this paper showing the luminous intensity at street surface with different lamps. In general it will be seen that the direct-current plants are the most favourable for places where the whole or nearly all the output is used for arc lighting—where but a small portion of the load is arc lighting, either the simple alternating systems or some of the systems transforming into direct continuous current by means of motor generators or rectifiers would be most practicable.

COMPARATIVE COST PER ARC LAMP PER YEAR OF 3,800 HOURS WITH DIFFERENT SYSTEMS.

No.	System.	Total cost per lamp in $.	I.H.P. per lamp.	Total operating expenses in $.
1	Hartford, 400 watts enclosed	146·50	0·744	52·86
2	Hartford, 450 watts enclosed	155·24	0·822	57·85
3	Alternate-current Ind. Reg., 400 watts enclosed	139·80	0·708	50·75
4	Direct-current arc driven by alternate-current motors, 300 watts enclosed...	131·42	0·630	46·03
5	Direct-current belted, 300 watts enclosed......................................	117·90	0·552	41·75
6	Direct-current arc, driven by direct-current motors, 300 watts enclosed	129·45	0·642	46·06
7	Direct-current arc belted, 450 watts enclosed	147·37	0·830	57·07
8	Direct-current arc belted, 450 watts open arc	142·60	0·832	68·53
9	Direct-current arc direct driven, 450 watts open direct current	142·00	0·810	62·58
10	Alternate-current Ind. Reg., 450 watts enclosed. No increase in generating plant	91·14	0·804	45·89
11	Direct-current arc driven by alternate-current motors, 450 watts enclosed. No increase in generating plant	100·40	0·948	53·93
12	Rectifier system, 450 watts enclosed ...	154·30	0·816	58·69
13	Incandescent, 3–50 c.p. lamps, 450 watts	121·75	0·766	60·85

L. J. S.

1202. *Lighting by Alternate-Current Arc and Incandescent Lamps.* **R. Fleming.** (Elect. World and Engineer, 35. pp. 133–134. **Discussion, pp.** *134–135,* Jan. 27, 1900. Paper read before the Eighth Annual **Convention of**

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the North-Western Electrical Association.)—The author advocates the use, as a system, of alternating-current enclosed arc lamps with constant current transformers and estimates that a saving of $8—$12 per lamp per year can be made over direct-current open arc lamps. In the discussion, the speakers confirmed the author's opinions, and some favourable results were quoted of working with 32-c.p. incandescent lamps in series. These lamps have a life of 4,000 to 5,000 hours. The most satisfactory size of enclosed arc is a lamp consuming from 425–440 watts at 6·6 amperes and 70–75 volts at the arc.

C. K. F.

1203. *Arc Lighting without Regulating Resistance.* **X. Gosselin.** (Soc. Int. Élect., Bull. 16. pp. 448–450; Discussion, pp. 450–467, 1899, and 17. pp. 100–106, Feb., 1900.)—In order to prevent undue variation of current, arc lamps are connected in series with a steady resistance in which 20 to 30 per cent. of the power is lost. To economise this power automatic devices may be employed which introduce a resistance only when the current exceeds the normal value. Three arc lamps can then be run in series across the 110-volt mains. Such lamps designed by Hegner, Vigreux, and Brillé are described.

In the discussion **Aliamet** pointed out that with alternating currents this economy may be effected with only two arcs in series by replacing the steadying resistance by a choking coil. Low voltage arcs are very short compared to those of normal voltage and give a correspondingly bad distribution of light, also the carbons are liable to fuse together instead of striking owing to sluggishness in the automatic regulator. With two arcs in series the extra resistance required can be obtained by reducing the section of the leads, thus effecting a saving in copper. **Hegner** pointed out the effect of the presence of mineral salts in the carbons in allowing a longer arc with reduced voltage, and described his lamp in detail.

L. B.

1204. *Lighting from Primary Batteries.* **F. E. Woodford.** (Amer. Electn. 12. pp. 92–94, Feb., 1900.)—The author proposes to use gravity cells, capable of giving half an ampere continuously for two months without attention, permanently connected in parallel with a battery of storage cells. When light is not required, the latter are automatically charged by the gravity cells which are in this way kept in good condition. An estimate is given for outlay, but the author does not go into the question of cost of running.

W. R. C.

1205. *Candle-Power of Arc Lamps.* **E. P. Warner.** (Elect. World and Engineer, 35. p. 66, Jan. 13, 1900. Paper read before the December meeting of the Chicago Electrical Association.)—This paper deals with the relative candle-power of direct and alternating enclosed arc lamps. It is illustrated with a diagram of two curves of photometric readings at different angles taken from two lamps with all conditions alike except that one was direct and the other alternating. There is a remarkable similarity in the distribution of light in the two, but the direct current exceeds the alternating current in light capacity by an average of about 12 per cent.

In order to correct the violet rays in the alternating lamp the author has used what is known as an alabaster globe. This is composed of two layers or thicknesses of glass, one of which is clear or slightly tinted with uranium, and the other opalescent. This acts on the violet rays somewhat similarly to a solution of quinine sulphate, and transforms the violet into white light, with, however, a material loss of light.

E. C. R.

1206. *Life Tests of Glow-Lamps.* **G. D. Shepardson.** (Amer. Electn. 12. pp. 76–77, Feb., 1900. Abstract of a paper read before the Northwestern Electrical Association.)—This paper deals with tests made on the candle-power and watts taken of batches of lamps rated at 16 c.p., and picked at random from the stocks of several American lighting companies. The lamps were first tested with an average result (for 55 lamps) of 18·3 c.p. and 55·8 watts, or 3·1 watts per candle. The initial candle-power varied from 14·1 to 23 and the watts from 47·3 to 71·8, or from 2·32 to 4·10 per candle. These lamps were all tested at their marked voltages. Lamps were then selected at random from the different lots obtained from the various sources, and were maintained continuously at the constant voltage they were marked for, tests being made every 24 hours. After 50 hours burning the candle-power varied from 8·2 to 23, the watts per candle from 2·32 to 4·1, the average being 17·5 c.p. and 3·27 watts per c.p.

After 100 hours the figures were from 10·1 to 22·3 c.p. and from 2·52 to 5·02 watts per c.p., the averages being 17.5 c.p. and 3·3 watts per c.p.; after 400 hours from 11·3 to 19 c.p. and from 3·00 to 4·81 watts per c.p., the averages being 16·0 c.p. and 3·54 watts per c.p.; after 600 hours 11·4 to 18·8 c.p. and 3·34 to 4·26 watts per c.p., the averages being 14·7 c.p. and 3·82 watts per c.p. A few lamps were burned from 800 to 900 hours, at which time the c.p. varied from 10·8 to 16·4, and the watts per c.p. from 3·6 to 4·4. Early in the test several of the lamps "burned blue," and their high efficiency pointed to short life. All of the lamps in one group had burned out in about 100 hours, whereas some of those in another group lasted 500 hours. Experiments were also tried on the behaviour of lamps on a circuit varying from 104 to 118 volts.

E. C. R.

REFERENCES.

1207. *Electrical Cabs in New York.* **G. Pellissier.** (Écl. Électr. 22. pp. 41–50, Jan. 13, and 88–92, Jan. 20, 1900.)—Two articles with several drawings showing design of the cabs, and also illustrating the method of charging the accumulators.

1208. *Automobiles for Transport.* **Bricka.** (Écl. Électr. 21. pp. 424–425, 1899.)—The author tabulates the relative cost per ton kilometre with transport by mules, carriages, and automobiles.

M. O'G.

1209. *Incandescent Lamps.* **G. Richard.** (Écl. Électr. 19. pp. 321–325, 1899; 22. pp. 206–212, Feb. 10, 1900.)—Description of Nernst, Phelps, H. and F. Angenault, Thomson-Houston, Lister, Wierre, Renous and Bronilawski lamps: Adams' mining lamp, and Stearn's method of manufacturing filaments (pp. 321–325). Methods of manufacturing incandescent lamps; some useful drawings are given (pp. 206–212).

1210. *Nernst Lamps.* (Écl. Électr. 22. pp. 142–144, Jan. 27, 1900.)—Description of patents by R. A. Fessenden in connection with contacts and methods of automatic lighting.

W. R. C.

1211. *Battery Regulation.* (Elekt. Runds. 17. p. 104, Feb. 15, 1900.)—A description of the method employed by the Cie. de l'Industrie Electrique, in which a charging and discharging booster connected in series with the cells replaces the usual battery regulating switch.

L. B.

1212. *Ingleton Central Station.* (Electrician, 44. pp. 578–583, Feb. 16, 1900.)—A description with illustrations and drawings. The dynamos are driven by water power, there being a fall of 27 feet available.

1213. *Incandescent Lamps.* **H. Remané.** (Zeitschr. Instrumentenk., Beib. 23. pp. 209–213; 24. pp. 221–227, 1899. Report read before the Zweigverein Berlin der D. G. f. M. u. O., November 7 and 21, 1899.)—This paper comprises a short history of the development of the incandescent lamp, a description of its manufacture as now practised and of its physical properties, and a list of the various uses to which incandescent lamps are applied. C. K. F.

1214. *Philadelphia Electric Company.* **C. W. Swoope.** (Elect. World and Engineer, 35. pp. 279–281, Feb. 24, 1900.)—A description of the central distributing station, which contains large biphase machines.

1215. *Polyphase Transmission.* **C. F. Scott.** (Journal of Electricity, S.F. 8. pp. 121–128, 1899. Paper read before the National Electric Light Association, March 1, 1894..)—An exposition of the general principles involved.

1216. *Peoria and Pekin Railway, U.S.A.* (Street Rly. Journ. 16. pp. 134–141, Feb., 1900.)—This is an instance of a railway worked both by steam and electricity. It is ten miles in length; a general description of its equipment is given.

1217. *Rail-Welding Train.* (Street Rly. Rev. 9. pp. 823–825, 1899.)—An illustrated description of the cupola car, the sand-blast car, the heater car, and the supply car, which together form the train used for cast-welding operations by the Calumet Street Railway Company, Chicago. E. H. C.-H.

1218. *Trolley Wires over Movable Bridges.* (Elect. Engin. 25. pp. 186–187, Feb. 9, 1900.)—The article gives particulars of the methods adopted for carrying the trolley wire over a movable bridge at Hull. Three drawings are given.

1219. *Drying Traction Motors.* (Street Rly. Journ. 16. p. 146, Feb., 1900.)—A short paragraph stating that in snowy or wet weather the Albany Railway Company adopts the plan of drying their motors in the car sheds. For this purpose they have 1¼ inch steam-pipes, placed parallel to and between the rails, and about 3 inches below the motors on the cars. Live steam is kept in these pipes through the night. This method has materially reduced the repair bill.

1220. *American Automobiles.* **F. B. Rae** and others. (Elect. World and Engineer, 35. pp. 92–95, Jan. 20; 129–130, Jan. 27; p. 173, Feb. 3, 1900.)

1221. *German Automobiles.* (Elect. World and Engineer, 35. pp. 207–209, Feb. 10, 1900.)—An article, illustrated by photographs, dealing with some modern designs.

1222. *Tramways in Berlin.* **D. B. Macgowan.** (Tram. Rly. World, 9. pp. 15–17, Jan., 1900, from the Chicago Tribune.)—A general statement as to the various tramways either projected or under construction. The tramways are operated in general on the mixed system, *i.e.*, trolley-wire system in the outskirts, and accumulators in the centre of the town, the accumulators being charged while the cars are on the trolley-wire section. The City gets 8 per cent. of the gross receipts in the case of the two largest companies; and whenever dividends exceed 12 per cent. one-half of the excess goes to the City.

1223. *Economy in Power-Stations.* **M. Hoopes.** (Elect. Rev. N.Y., 35. pp. 226 and 243, 1899.)

TELEGRAPHY AND TELEPHONY.

1224. *Submarine Cable Signals.* **A. Jamieson.** (Inst. Engin. and Shipbuilders, Trans. 43. pp. 34–45, Feb. Discussion, pp. 38–41, March, and pp. 17–20, April, 1900; also Electrician, 44. p. 789, March 23, 1900.)—The Cape Town shore-end of the main cable to Mossamedes passes round the south-eastern curve of Table Bay. Electric tramway trolley lines are suspended overhead from Wynberg to Cape Town, almost parallel to the cable, at a mean distance of about half a mile from the shore-end. The condition of affairs is further complicated by subterranean lines running close to the tramway rails. To check the disturbing effect of the tramway circuit upon the signals, a cable of about 5 n.ms. was laid as nearly as possible over the shore-end of the main cable, and connected to the earth side of the recorder, the sea end being earthed to its own sheathing. This device resulted in improved signals. But an extension of the tramway rendered it necessary to lengthen the subsidiary cable to 11 n.ms. It is now suggested to adopt the Hughes' method, using a twin twisted core, with double armouring. Further it is recommended that the tramway company should adopt a sufficient number of boosters to reduce the return currents in the rails. R. A.

1225. *Duplex Telegraphy in Belgium.* **Buels.** (Soc. Belge Élect., Bull. 17. pp. 68–80. Discussion, pp. 80–87, Feb., 1900.)—An explanation is given of the means adopted to balance the capacity and self-induction of the line circuit upon the differential duplex. It is observed that these phenomena, while producing opposite effects upon the relay in circuit at a sending station, do not by any means compensate each other. Want of balance as regards these qualities in the artificial line gives "kicks" of different senses in the instrument. The means of entirely relieving the relay (English P.O. standard) of disturbances when the sending key is operated have been studied, and the results are that the artificial line is composed of two electromagnets, horseshoe form, having each a resistance of 500 ohms, with movable cores by which the inductance can be regulated. Between these is a non-inductive resistance to balance the rest of the non-variable line resistance. The condensers were attached to this and can be adjusted at will by ordinary methods. A condenser of small capacity (½ to 1½ m.f.) is also permanently attached to the extremity of the artificial line nearest the relay. The English P.O. relay is found to be very sensitive for indicating balance, and as the Hughes apparatus is used on the Belgian duplex circuits this is of great importance. A slight want of balance does not affect Morse instruments in their functions, but absolute compensation is required with the Hughes to prevent distortion of signals. It is also necessary that they should be quite detached one from another, and to this end the real and artificial lines are joined in shunt across the relay by a resistance having strong self-induction, which acts to quickly restore the armature of the relay upon the cessation of a signal. This is the device of M. J. Pierart. E. O. W.

1226. *Contact Force of Metals used for Working Telephones.* **E. Piérard.** (Soc. Belge Élect., Bull. 17. pp. 88–93, Feb., 1900.)—A "vibrator" or periodic *interrupter*, consisting of a metallic disc fixed as in a Bell telephone receive

with a platinised point suitably placed behind its centre, but not quite touching it, the disc and point being joined respectively to the two-line wires, will transmit musical notes to a distant receiver, the electromotive force arising from the contact of the disc and the point where the former is pressed inward upon the latter. It is, of course, only upon closing such a circuit that an impulse is transmitted and consequently fundamental sounds are reproduced and harmonics excluded. By interposing an induction coil in the usual way the sounds in the receiver were magnified. It might be supposed that the effect was voltaic or thermic, or perhaps both, since the breath may cause a difference of temperature. The author examines this question, firstly trying discs of various metals and alloys. Some were successful, and with some no sound was obtained ; but in all cases but one, if a little disc of platinum was soldered to the back centre of the large disc so as to come into contact with the point when the movement occurred, the force was present and sounds heard with more distinctness in all cases. The temperature was next kept constant and, instead of applying the mouth to the "vibrator" it was caused to move by the beat of a wooden drumstick, when the sounds were found to be reproduced. Again, if a copper-toothed wheel turning upon an axle of iron is introduced into the circuit in place of the vibrator and one end of the copper wire of the primary caused to make intermittent contact with the teeth while the other end touches the copper nave, no sound is heard. But if the second wire is removed from the nave and is caused to touch the iron axle, all the interruptions are heard in the receiver. The author concludes then that the effect is not thermoelectric, but due to both the contact of dissimilar metals where such are employed, and to the states of their surfaces being different. E. O. W.

1227. *Telephone Exchange : St. Louis, U.S.A., Kinloch Tel. Co.* **F. E. Bausch.** (Elect. World and Engineer, 35. pp. 5–10, Jan. 6, 1900.)—Full description with illustrations of the St. Louis "independent" telephone exchange. All subscribers are brought to one exchange in which is a Kellogg divided multiple switchboard. The switchboard is in four parts, A, B, C, and D. Each division consists of ten sections. Each section is fitted with multiple jacks for one-fourth of the lines entering the exchange. An indicator and an answering jack for every line appear in each of the four divisions. The equipment is for 8,800 lines ; thus each section has 880 indicators and 880 incoming call (or answering) jacks. Each subscriber's station is equipped with a magneto generator and four keys with commutator springs and connections for operating any one of four indicators at the exchange switchboard. The keys are designated A, B, C, and D respectively and correspond with the four divisions of the switchboard. The commutator springs and connections of the keys permit the selection for operation (method described) of one out of the four indicators attached to each line. The subscribers are designated A1, B1, C1, D1, &c. Any subscriber requiring a subscriber in class D presses key D and rings ; his indicator will fall in division D of switchboard, where all D subscribers are multipled, when the connection is completed in the ordinary way. The clearing-out signal is operated by depressing any one of the four keys at the subscriber's station. It is stated that automatic calling and clearing will be installed this year. J. E. K.

1228. *Selective Telephone Signals.* **H. S. Webb.** (Amer. Electn. 12. pp. 94–97, Feb., 1900.)—The author describes a new selective signalling system for any number of telephone offices up to eight, upon one and the same cir-

In this case, if the oil were set in motion with a velocity v, the velocity of the waves through it would be increased by the amount

$$v \, D/(D + d).$$

This fraction is of the same form as that called for by the aberration of light and Fizeau's experiment. Consequently, taking κ to be a density, we should have for all substances the fraction $(\kappa - \kappa_e)$/density, approximately equal to a constant, where κ_e denotes the dielectric constant of the ether. There are exceptions, such as water and the alcohols, but by far the greater majority of substances obey this law. Now since κ denotes the dielectric constant, and therefore the density, both of the stuff and the space occupied by it, and, according to our present system, that of the ether alone is unity, therefore $(\kappa - 1)$ is the density of the material in terms of the density of the ether. Now the average value of the constant, $\frac{\kappa - 1}{\text{density}}$, is 1·5, therefore the value of the density of the material in terms of the density of the ether is 1·5 times its density in terms of water, *i.e.*, the density of the ether is 0·66, or two-thirds that of water. The elasticity is then deduced from the known velocity of light.

Conversely it follows that to find the dielectric constant of any substance, it is sufficient to add its specific mass to that of the ether and then divide the sum by 0·66. Thus, to get the dielectric constant of a mineral oil of density 0·5, we get—

$$(0{\cdot}5 + 0{\cdot}66) \div 0{\cdot}66 = 1{\cdot}75 = \kappa.$$

[The remainder of this paper is dealt with in Abstracts Nos. 1234, 1235, 1277, 1278, and 1279 (1900).] E. H. B.

1234. *Size of Atoms and their Ionic Charges.* **R. A. Fessenden.** (Phys. Rev. 10. pp. 1–33. Jan., and 83–115, Feb., 1900.)—In the course of an investigation directed chiefly to other ends the author is incidentally led to discuss the size and properties of atoms and their ionic charges. He thus arrives at the following inferences:—

(1) The space occupied by the atoms of a metal to the exclusion of other atoms is of an approximately spherical shape at ordinary temperatures. (2) The atoms of a metal, when in a solid state, are not widely separated, but the shortest distance between the surfaces of two adjacent atoms is of the order of 1 per cent. of the diameter of the atom itself, when at temperatures not near the fusing-point. (3) Metalloids differ from metals in that their atoms have not an approximately spherical shape. (4) The melting-point and expansion of the elements is a function of the shape of their atoms. (5) The diameter of the mercury atom is 2·75 $(\pm 0{\cdot}2)\, 10^{-8}$ cm. (6) The ionic charge is 4 $(\pm 1)\, 10^{-10}$ *E.S.* units. (7) Chemical action and cohesion are both manifestations of the same force, *i.e.*, electrostatic attraction, under different conditions. (8) If we take wires of two pure metals, having an equal number of molecules in the cross section, then the electrical resistances of the wires will be proportional to the times taken by a sound wave to traverse them. Van der Waal's equation is also examined in the light of this theory and the constant a shown to be a function of the volume b, so that the equation would be modified thus—

$$\left(p + \frac{c}{b^{4/3}}\right)(v - b) = RT.$$

[The remainder of this paper is dealt with in Abstracts Nos. 1233, 123 1277, 1278, and 1279 (1900).] E. H.

1235. *Elasticities of Substances in terms of their Atomic Volumes.* **R. A. Fessenden.** (Phys. Rev. 10. pp. 1–33, Jan., and 33–115, Feb., 1900.)—On the author's theory of atoms the following formulæ hold :—

(1) Rigidity $= 28 \times 10^{12} \div (\text{atom. vol.})^2$.

(2) Young's Modulus $= 78 \times 10^{12} \div (\text{atom. vol.})^2$.

(3) Velocity of Sound $= \left\{78 \times 10^{12} \div (\text{atomic wt.} \times \text{atom. vol.})\right\}^{\frac{1}{2}}$.

These are supported by tables showing a fair agreement between the experimental and theoretical values for iron, copper, platinum, zinc, silver, gold, aluminium, cadmium, magnesium, tin and lead.

[The remainder of this paper is dealt with in Abstracts Nos. 1233, 1234, 1277, 1278, and 1279 (1900).] E. H. B.

1236. *Impact Tests of Material in Tension.* **W. K. Hatt** and **E. Marburg.** (Eng. News, 43. pp. 74–75, Feb. 1, 1900. From a preliminary report read before the American section of the International Association for Testing Materials.)—The authors briefly review the early experiments, and the more recent experiments of Kirkaldy and Le Chatelier. They then describe some slow tension-tests and tests in longitudinal shock made at Purdue University during the past two years on iron and steel wires from $\frac{1}{8}$ inch to $\frac{1}{2}$ inch diameter, ranging in length from 4 feet to 9 feet. The machine used is of a type in which the hammer is hung on the specimen and impact takes place at the upper head. The hammer varies from 345 to 1,230 lbs., and the range of motion is from $\frac{1}{2}$ to 7 feet. The anvil on which impact occurs at the upper head consists of two oak pieces 4 inches square in section bridging the 20 inches clear span between the uprights of the machine, supporting a cast-iron block 14 in. × 18 in. × 6 in., which in turn supports a steel block 4 in. × 4 in. × 14 in. A pencil attached to the hammer describes a curve on the surface of a revolving drum, whose speed is determined by the record of a tuning-fork. The total elongation of the specimen is thus recorded on the drum, as well as the velocity of the weight before and after impact. A summary of the observations shows that the ultimate extension, contraction of area and resilience were not different for Norway iron and medium steel wire $\frac{1}{2}$ inch diameter under slow loading and under impact. One specimen broke in two places, and in other cases more than one neck developed in the specimen. In impact on wires of smaller diameter, the elongation in different foot-lengths varied irregularly, while in slow tension-tests on the same material the elongation decreased regularly on each side of the fracture. In thick wires the elongation was as uniformly distributed in slow as in rapid tests.

Detailed results will be published when the investigation is sufficiently advanced. A. S.

1237. *Elasticity and Strength of Copper.* **C. Guidi.** (Accad. Sci. Torino, Atti. 35. 6*a*. pp. 223–230, 1899–1900.)—This paper contains the results of experiments on the elasticity and resistance to tension of bars of copper made from plates employed in the construction of the fire-box of a locomotive. It is known from the experiments of Bach that repeated tests of ever-increasing intensity increase the elasticity of a bar. Owing to variations of pressure within the boiler the plates of a fire-box are subjected to varying strains. The increase in elasticity, however, in the cases studied is not large, and the elasticity is less than half of that which can be obtained artificially by the method of Bach. Tables and curves accompany the paper. A. G.

1238. *Viscosity of Argon as Affected by Temperature.* **Rayleigh.** (Roy. Soc., Proc. 66. pp. 68–74, March 8, 1900.)—The author prefaces the account of his experiments with some interesting theoretical considerations. After having shown why one might expect the Maxwell law to hold, *i.e.*, the non-dependence of μ (viscosity-coefficient) on density, it is shown that if this law be assumed, and if the repulsive force between the molecules vary as r^{-n}, then for a given kind of molecule $\mu \propto \theta^{\frac{n+3}{2n-2}}$ where θ = temperature. This theorem is proved in a very simple manner by an application of the method of dimensions. For the case of sudden impacts, $n = \infty$ and $\mu \propto \theta^{0.5}$. But the best experiments on air show that $\mu \propto \theta^{0.77}$. In the hope of obtaining a better agreement between theory and experiment in the simpler case of *monatomic* molecules experiments were made on the viscosity of argon at room temperature (15° C.) and at the temperature of boiling water (100·27° C. in this particular case). The method of flow through a capillary tube was employed. The capillary tube was nearly 5 feet long, and was surrounded by a jacket through which steam could be passed. All joints were blown. The experiments being comparative, it was not necessary to keep the driving pressure constant. The mean of the time measurements was correct to $\frac{1}{10}$ sec. These means were: 15° C., 104·67 secs.; 100·27° C., 167·58 secs. This gives $n = 0{\cdot}812$ in the formula $\frac{\mu'}{\mu} = \left(\frac{\theta'}{\theta}\right)^n$, when θ = absolute temperature. Corrected for the expansion of the glass, this becomes 0·822. The following table embraces the results of an extended series of observations :—

Air (dry)	0·754
Oxygen	0·782
Hydrogen	0·681
Argon (impure)	0·801
Argon (best)	0·815

The numbers in this table are the values of n in the above formula, corrected for the expansion of the glass.

It will be seen that the value of n for argon is not equal to values such as 0·5 or 1, to which theoretical considerations lead. F. G. D.

1239. *Argon Passing through Rubber Films.* **Rayleigh.** (Phil. Mag. 49. pp. 220–221, Feb., 1900.)—Graham found that when air was allowed to percolate through rubber films into a vacuum, the oxygen percentage instead of being 21 was about 40. The author finds the mean percentage to be 37. Of 3,205 c.c. of percolated air 1,185 was oxygen, and of the remaining 2,020, 1,981 consisted of nitrogen and was oxidised out, leaving 39 c.c. of argon, or 1·93 per cent. of the 2,020. In atmospheric air the proportion of argon in the mixed nitrogen and argon is (Kellas) 1·19 per cent. Argon, therefore, passes through an indiarubber film more readily than nitrogen, but not in such degree as to render the diffusion process a useful one for the concentration of argon from the atmosphere. A. D.

1240. *Theory of Diffusion.* **O. Wiedeburg.** (Zeitschr. Phys. Chem. 30. pp. 586–592, Dec. 30, 1899.)—This paper is to some extent a criticism, and to some extent a continuation of an article by E. Bose (see 1900, Abstract No. 15). For the criticism, which chiefly refers to certain implicit assumptions, reference should be made to the original paper. An endeavour is made

to calculate the value of the velocity of a gramme-molecule (un-ionised) of a substance dissolved in water when subjected to a unit force. The variation of the coefficient of diffusion with change of concentration may be expressed by the empirical equation $D = D_0(1 + \gamma c)$, where D is the value for concentration c, and D_0 the value for zero concentration, γ being a constant which depends on the nature of the solution. When $\frac{4c}{k}$ (for meaning of k and other symbols see the Abstract mentioned above) is small compared with unity, it can be shown that $W = (2 + \gamma k)\frac{UV}{U+V}$ approximately. The smaller γ and k, the more accurate the simple formula $\frac{1}{W} = \frac{1}{2}\left(\frac{1}{U} + \frac{1}{V}\right)$. A shot is made at the value of W in the case of an aqueous solution of salt at 18°, of such a strength that the grade of dissociation is one-half. Taking U and V in the usual units (reckoned for infinite dilution), the respective values are 41×10^{-7}, 62×10^{-7}; and W (the value of γ being obtained from certain experiments of Wroblewski) comes out to be 54×10^{-7}. A. G.

1241. *Electrification and Surface Tension.* **E. Merritt** and **S. J. Barnett.** (Phys. Rev. 10. pp. 65–78, Feb., 1900. Paper read before the American Physical Society, Dec. 28, 1899.)—Since the electro-capillary phenomena occurring at the interface between a liquid metal and an electrolyte, as in a capillary electrometer, are due almost entirely to true alterations of surface tension resulting from the chemical changes of electrolysis, it is interesting to inquire whether there are any alterations of surface tension produced directly by electrification. In a charged soap-bubble the expansion is not due to a diminution of the surface tension, but to electrostatic forces. To eliminate the latter the surface tension was studied by Barnett's method of capillary ripples, a surface of water or mercury being made one armature of a condenser, while a metallic plate forming the other was mounted above it. The velocity of propagation of the ripples with or without electric charge was such as to show no perceptible direct variation of the surface tension, after allowing for the effect of the electrostatic force. E. E. F.

1242. *Internal Friction of Water.* **G. Pacher.** (N. Cimento, 10. pp. 435–448, 1899. From Atti del R. Instituto Veneto, 58. 2. pp. 784–814, 1898–1899.)—In the neighbourhood of 4° the coefficient of viscosity of distilled water presents an anomaly which expresses itself in a flexure of the curve of the coefficient as a function of the temperature. The anomaly in question consists of a maximum and a minimum between 4° and 5°. In view of the connection known to exist between the viscosity and the resistance it is very probable that a similar anomaly occurs in the resistance of distilled water and of aqueous solutions. The author suspects a connection between the anomaly described and the anomaly in the resistance of aqueous solutions discovered by Lussana. E. E. F.

1243. *Electric Thermostat.* **W. Duane** and **C. A. Lory.** (Amer. Journ. Sci. 9. pp. 179–182, March, 1900.)—An electric thermostat is employed by the authors capable of keeping the temperature of a bath of 150 litres capacity constant to within 0·0005° C. The bath is filled with a solution of common salt and heated by an alternating current, the circuit being opened or closed by a mercury contact actuated automatically by the expansion and contraction

of alcohol contained in a system of brass tubes immersed in the bath. The apparatus can be adjusted to any required temperature, and is extremely sensitive, opening and closing the circuit several times per second if the temperature tends to vary. L. B.

1244. *Mechanical Principles of Flight.* **Rayleigh.** (Manchester Lit. and Phil. Soc., Mem. 44. 5. pp. 1–26, 1899.)—This lecture is occupied chiefly with the mechanics of soaring, or the sailing flight of birds with motionless wings. It was previously shown, in 1883, that "whenever a bird pursues his course for some time without working his wings we must conclude either (1) that the course is not horizontal; (2) that the wind is not horizontal, or (3) that the wind is not uniform." The third case is most fully discussed. In a uniform wind the available energy at the disposal of the bird depends upon his velocity *relatively* to the air about him. Thus elevation may be gained proportional to the loss of relative velocity squared. Let the wind blow horizontally with velocity $+u$ above a certain plane and velocity $-u$ below it. Let a bird sailing above the plane of separation have initial relative velocity v and consider how he might take advantage of his circumstances. Let him first, if necessary, turn round until the relative motion is down wind in the upper stratum, and, second, drop through the plane of separation. In passing through this plane there is a really effective gain. In entering the lower stratum the relative velocity is increased from v to $v + 2u$. This corresponds to a gain of potential elevation equal to $2u(u + v)/g$. At this stage the bird is moving against the direction of the wind in the lower stratum. He next turns round so as to be with the wind of the lower stratum and contrary to the wind of the upper stratum. A passage upwards through the plane now secures another gain of relative velocity, or of potential elevation, of nearly the same value as before. An example is given showing that a difference of wind-velocity of 4·7 miles per hour above and below the plane of separation corresponds to a potential elevation of 10 feet each time the bird crosses the plane properly with a speed of thirty miles per hour. The article also shows how a bird may take advantage of the *gustiness* of the wind. The behaviour of aeroplanes is next discussed at some length, both mathematically and experimentally.
E. H. B.

1245. *Lecture Demonstrations of Wave Motion.* **W. C. Baker.** (Phys. Rev. 10. pp. 175–177, March, 1900.)—A mercury tray, 72 × 55 × 7 cm., whose smooth bottom is painted white, is filled to a depth of about half a centimeter with water, slightly darkened with ink. The discoloration of the water must be such that the bottom of the tray is clearly visible through the layer of liquid when at rest. If a beaker or other round vessel of 8 to 10 cm. diameter is placed in the tray a circular wave is set up that spreads in all directions. The motion of this wave can be clearly followed, as the thickness of the liquid at the crest of the wave being so much greater than at the trough, the appearance is that of a dark band travelling over a lighter background. The removal of the beaker gives a second wave, so if the beaker be kept moving with a period of one or two seconds a train of waves of the same period is produced. The use of single waves or trains of only two or three is advocated in order to avoid interference effects after reflection at the sides. These circular waves travel at from 15 to 25 cm. per sec., and the growth of the waves reflected from the sides of the tray can easily be followed on account of their slow motion. Waves approximately plane are obtained by using a a block of wood about 50 × 8 cm. instead of the beaker. A semicircular

piece of barrel hoop placed at one end of the tray plays the part of a concave or convex mirror. Refraction phenomena are represented by the use of a piece of window glass, say 60 × 12 cm. placed about 1 mm. below the surface of the liquid and strictly parallel thereto, care being taken that its surface is thoroughly wet. Trains of circular waves passing over this shoal travel slower, decrease in curvature, and have a smaller wave-length. Following the same principles refraction through prisms and lenses may be imitated and illustrations of Huyghens' principle and diffraction readily given. E. H. B.

1246. *Variation of Atmospheric Pressure and Moon's Declination.* **R. Börnstein.** (Phys. Zeitschr. 1. pp. 54–56, 1899. Report read before the Naturforscherversammlung in Munich.) — The variations of standard barometers have been carefully studied for eighty sidereal months (from January 1, 1893, to December 24, 1898, and the results plotted in comparison with the different positions of the moon in declination at Berlin, Magdeburg, and Potsdam. It is found that a *maximum* pressure generally occurs about the eleventh or twelfth day of the lunation, and a *minimum* about the twenty-third, the amplitude of the variation depending on the latitude of the place. For example :—

Amplitude at Berlin (52° 31′ 54·3″ N.) = 2·851 mm.
„ Magdeburg (52° 7′ 46″ N.) = 2·764 mm.
„ Vienna (48° 15′ N.) = 1·853 mm.
„ Upsala (59° 51·5′ N.) = 1·945 mm.
„ San Fernando (36° 27′ 41·5″ N.) = 0·768 mm.
„ Port au Prince (18° 34′ N.) = 0·692 mm.
„ Batavia (6° 11′ S.) = 0·141 mm.

C. P. B.

REFERENCES.

1247. *Aerial Locomotion.* **H. Wilde.** (Manchester Lit. and Phil. Soc., Mem. 44. 11. pp. 1–16, 1900.)—Consists chiefly of descriptions of experiments in aeronautics which have yielded only negative results. A parachute with vibrating framework is suggested as a possible solution of the problem. E. H. B.

1248. *Construction of the Curve $PV^n = C$.* **D. A. Low.** (Mech. Eng. 5. pp. 292–293, March 3, 1900.)—A paper describing a simple method of drawing any number of curves of the form $PV^n = C$, and showing how to find out whether a given curve is of this form, and if so, showing how to find the value of the index n. A. S.

1249. *Horizontal Pendulum in Seismometry.* **G. Agamennone.** (Accad. Lincei Atti, 9. pp. 107–114, Feb. 18, 1900.)—This paper describes various examples. A. G.

LIGHT.

1250. *Nature of White Light.* **E. Carvallo.** (Comptes Rendus, 130. pp. 401–403, Feb. 12, 1900.)—The author proposes the following crucial experiment, whose realisation is conceivable, to decide the point at issue between M. Gouy and himself [see Abstracts Nos. 817, 818, 819 (1900)] : Let the spectroscope be reduced to a concave grating, and let the grating be enlarged in the proportion of sound waves to visible light waves. Finally, let the source of light be replaced by a tuning-fork. If the tuning-fork is electrically driven, it will produce a sinusoidal wave train. At the focus of the spectroscope, we should find sonorous points corresponding to the rays emitted by monochromatic light. Let the tuning-fork be stopped. Its vibrations will be damped, and certain processes permit of the variation and regulation of the damping. If, under such circumstances, a sound spectrum is found to exist, there will be a confirmation of Gouy's views. If, on the other hand, the sound is everywhere the same, with an intensity varying according to the point of the focal surface, and the sound is extinguished with the vibration of the tuning-fork itself, then the author's own views are verified.
E. E. F.

1251. *Duration of Faraday Effect.* **H. Abraham** and **J. Lemoine.** (Comptes Rendus, 130. pp. 499–501, Feb. 19, 1900.)—By the method used for determining the duration of the Kerr effect (see 1899, Abstract No. 1859), the authors have also tested the existence of a time-lag in the Faraday effect. They find that the magnetic rotatory polarisation decreases by one-half in 1/100th of a micro-second, and is nearly zero after the lapse of double that time. Practically, therefore, both the Faraday effect and the Kerr effect follow the changes of the field without retardation. E. E. F.

1252. *Spectrum of Cyanogen.* **W. N. Hartley.** (Roy. Dublin Soc., Proc. 9. pp. 289–297, April 7, 1900.)—The paper chiefly consists of a reply by the author to a criticism of his former work by Eder and Valenta. He also describes his observation of the cyanogen bands in the spectrum of an oxy-coal-gas flame, the presence of the cyanogen being subsequently proved chemically by passing the gas through alkaline ferrous sulphate and final precipitation of Prussian blue in the usual manner. C. P. B.

1253. *Reference-Points in Spectra.* **M. Hamy.** (Comptes Rendus, 130. pp. 700–701, March 12, 1900.)—The author refers to a previous paper by Fabry and Perot, in which they imply that the red lines of cadmium used by Hamy and Michelson are not identical. Hamy explains this by stating that with Michelson's tube containing *internal* electrodes the red cadmium line at λ 508 is a doublet, one component strong, the other feeble; with external electrodes to the tubes, however, Hamy finds this same line to be a triplet, or a doublet having equal components, with a simple line on the less refrangible side. For practical work he finds these tubes without internal electrodes much more constant than the usual form. C. P. B.

1254. *Series in Spectra.* **E. A. Partridge.** (Frank. Inst., Journ. 149. pp. 198–206, March, 1900.)—A most useful review of the present state of knowledge respecting spectral series, containing references to most of past publications on the subject, from Lecoq de Boisbaudran's first paper in 1869 to the present time. The nearest approach to an accurate formula was that of Balmer, in 1885, which was, however, only applied to the hydrogen spectrum. In 1888 Kayser and Runge, of Hanover, announced the discovery of a more universal formula, of which that of Balmer was a special case, and from that time they have been engaged in successively photographing the elements of the various periodic groups and searching their spectra for series. It is found that the percentage of lines falling into series in any spectrum is almost inversely proportional to the melting-point of the element. The contemporaneous work of Humphreys on the effect of pressure on change of wave-length goes to confirm much of Kayser and Runge's series determinations, as he finds that all the lines in any one series have the same "displacement" due to pressure, but the amount varies for the different series. C. P. B.

1255. *Anomalous Dispersion in Infra-Red.* **E. Aschkinass.** (Phys. Zeitschr. 1. pp. 53–54, 1899. Report read before the Naturforscherversammlung in Munich.)—This paper is similar to that noticed in Abstract No. 626 (1900), but gives a few further results. Thus bands of anomalous dispersion occur at the following positions :—

Calcspar	6·67 μ and 11·40 μ.
Marble..................................	6·69 μ „ 11·41 μ.
Gypsum	8·69 μ.
Alum	9·05 μ.
Sodium bromide	50–55 μ.

C. P. B.

1256. *Fluorescence of Metallic Compounds caused by Röntgen and Becquerel Rays.* **P. Bary.** (Comptes Rendus, 130. pp. 776–778, March 19, 1900.)—The only salts, besides the phosphorescent uranium salts, which show fluorescence under the action of the Röntgen rays are compounds of the alkali or alkaline earth metals. On all these substances, a list of which is given, the Becquerel rays exert a similar action. T. H. P.

1257. *Radio-active Bodies.* **M. and Mme. Curie.** (Soc. Franç. Phys., Bull. 142. p. 6, Jan. 19, 1900.)—Polonium (which chemically resembles bismuth) falls off slowly in its radio-active power. Radium (similar to barium) seems to have a higher atomic weight than barium, for the atomic weight of barium seems higher (146) in radiferous barium compounds than it does (137) in compounds free from radium. The solid compounds of radium become more radio-active as time goes on, and do not reach their maximum activity within a month ; their initial condition is restored by dissolving them and recrystallising. The chloride and bromide of radium are the most brightly luminous compounds ; but all the salts are so to some extent. Induced phosphorescence and induced radio-activity in the neighbourhood of radium as described by Becquerel were discovered by the authors. Radium rays act in many ways like light ; they reduce silver salts, peroxide of iron, and bichromate of potash in presence of organic substances : but they also colour glass, porcelain, and white paper, and they transform greenish-yellow platinocyanide of barium into a brown variety. Giesel had prepared platinocyanide of barium with a trace of radium ; this spontaneously became

brown and then it polarised light like tourmaline. He also found that radium rays coloured rock-salt just as kathode rays do, or the vapours of the alkaline metals; and further, that radium salts, brought near to the temples or to the closed eyes, produced a sensation of light. A. D.

1258. *Curvature of Becquerel Rays.* **R. J. Strutt.** (Roy. Soc., Proc. 66. pp. 75–79, March 3, 1900.)—This is an attempt to compare the magnetic deflections of Röntgen, Becquerel, and kathode rays. The author entirely failed to obtain any sign of the magnetic deflection of Röntgen rays. He can assert with certainty that with a field of 3,270 c.g.s. units no perceptible deflection is obtained, and in view of the probable limit of sensitiveness of his apparatus, he says that to produce a curvature of radius 1 cm. in Röntgen rays a magnetic field would be required of at least 60 million units. Thomson has found that to produce the same curvature in kathode rays a field of only 315 units is required. Becquerel rays stand between Röntgen and kathode rays in this respect. The author arrives at an estimate of their curvature by placing a little lead box containing a uranium preparation on its side on a sensitive plate in a magnetic field. The box is only half full, and he adjusts the magnetic field until the rays are so deflected away from the plate that they only just graze the surface. It is then easy to draw the trajectory of the highest ray. A field of 1,680 units gives a field of curvature 3 cm. Hence a radius of 1 cm. would require 5,000 units. E. E. F.

1259. *Phosphorescence under Radium Radiations.* **H. Becquerel.** (Journ. de Physique, 9. pp. 65-70, Feb., 1900.)—Many recognised fluorescent substances become luminous in the neighbourhood of radium compounds: those excited by luminous rays (ruby and some calcareous spars) do not; those excited by ultra-violet rays or by Röntgen rays do so as a rule, but not in all cases or with equal intensities. There appears to be a certain amount of absorption by the air. The same screens have different effects in reducing the phosphorescence excited in different substances, so that each phosphorescence appears to be excited by a different part of the radium radiations. In some minerals the phosphorescence excited by radium is very persistent. Radium has the same power as the electric spark, or the prolonged action of violet or ultra-violet rays, of restoring the phosphorescent properties, under exposure to heat, of a body deprived of them by over-heating. Phosphorescence, and the temporary acquisition of a power of rendering air a conductor, both induced by radium radiations, are phenomena independent of one another: fluorspar may be deprived of the latter power by washing it in water, without affecting its phosphorescence. **Wyrouboff** pointed out (Soc. fr. Phys., Bull. 140, discussion, pp. 3–4, 1899) that the phosphorescence of fluorspar was a complex phenomenon; that the colours of spar were due to hydrocarbons and that white specimens did not phosphoresce on heating, and that if the hydrocarbons are destroyed by heat the spar can no longer fluoresce; and that therefore the action is a chemical one, which, however, is not combustion, for it is unaffected by an atmosphere of carbonic acid or of hydrogen. **Villard** pointed out that as to the violet colour induced in fluorspar by kathode rays (but not obtained by Becquerel with radium rays), this was not of the same nature as the violet coloration induced in glass by radium rays (M. and Mme. Curie); in the former case a subsalt is formed, in the latter there is oxidation of manganese. **H. Le Chatelier** said that as to this oxidation of manganese there was no occasion to call in oxygen from without; *there* was a disturbance of the existing chemical equilibrium between

manganous and ferric silicates, a disturbance brought about slowly by sunlight, quickly by radium rays. This chemical equilibrium is properly one pertaining to the high temperature of fused glass, and not to ordinary temperatures: and there is a constant tendency to the disturbance which the radium rays facilitate. A. D.

1260. *Radium Radiations in a Magnetic Field.* **H. Becquerel.** (Journ. de Physique, 9. pp. 71–78, Feb., 1900. Soc. Franç. Phys., Bull. 140. pp. 2–3; discussion, pp. 3–4, 1899.)—The radiations from radium are deviated in a magnetic field, being concentrated upon the poles in a non-uniform field. Rays in the same direction as a uniform field are not deviated; those in a plane at right angles to the field are deviated along circular lines. Between opposed polar faces, when the electromagnet is not excited, the phosphorescence or photographic effect is widespread and weak; when the electromagnet is set in action the area affected is narrowed and the effect is more intense. When the radium compound and the fluorescent substance are arranged on surfaces parallel to the lines of force, putting the electromagnet in action diffuses the effect, and the rays are bent curvilinearly, so that shadows cannot be produced unless this is kept in view. With polonium the predominant result (Curie) is that there is no such deviation. Radio-active bodies, therefore, give out two kinds of rays, deviable and not deviable in a magnetic field. **Curie** pointed out that these properties were like those of kathode rays, while in other respects radium rays were very like Röntgen rays. **Becquerel** replied that the phenomena of phosphorescence brought radium rays near to ultra-violet rays. A. D.

1261. *Radiations from Radium.* **H. Becquerel.** (Comptes Rendus, 130. pp. 206–211, Jan. 29, and 372–376, Feb. 12. Soc. Franç. Phys., Bull. 144, pp. 2–3; discussion, pp. 3–4, Feb. 16, 1900.)—The radiations from radium, transmissible through black paper and deviable by a magnetic field, are deviated to the same extent whether they travel in air or in a vacuum. The different salts of radium give out rays equally deviable, that is to say, of the same nature, and only differing in their intensity. Rays travelling normally to a uniform magnetic field describe a closed trajectory which brings them back to the point of emission: very much as in the case of kathode rays, and as if we had to do with forces acting upon negative electric masses traversing the magnetic field with high velocity. In a magnetic field aluminium and most other substances seem to be more transparent to these rays close to the source than they are at a distance of 2 cm. On the assumption of negative electric masses at high velocities, the masses and charges might be small, but the ratio m/e appreciable. Then as $v.m/e = H\rho$, where v is the velocity and ρ the radius of curvature of the trajectory, H being found equal to 4,000 and ρ to 0·37 cm., $v.m/e$ would be about 1,500; which is of the same order as the values found for kathode rays by J. J. Thomson, W. Wien, and Lenard. In an electric field of intensity F, the deviation should be $\theta = Fl/(v^2 m/e)$, where l is the length of path in the field. No deviation has as yet been obtained; but if v be, as in the case of kathode rays, of the same order as the velocity of light, say one-fourth as great, a deviation of $\frac{1}{5}$ radian or 11·4° on a trajectory of 1 cm. would require a potential difference of 20,000 volts between two plates 1 cm. apart. Experiments under such conditions have not yet been made. The part of the rays from radium deviable by a magnetic field is dispersed along trajectories with different radii of curvature, the absorption of which by different screens varies with the nature and the position of these

screens. Even lead is fairly permeable by the rays when quite close to the radium salts. The radium radiations seem to form a kind of continuous spectrum, for each part of which the value of $H\rho$ may be taken as its characteristic, and the absorptions of different substances may be characterised by finding the minimum values of $H\rho$ for the radiations which are transmitted by them. Those rays which have the smallest values of $H\rho$ and are most deviable are the most readily absorbed. **P. Villard** said the anomaly of unequal transparency at distant and at close quarters might be explained on the analogy of kathode rays, where the plate of aluminium interposed is not a simple transmitter of kathode rays, but always sends them normal to its surface, acting as a secondary kathode (J. J. Thomson); and in Becquerel's experiments the interposed plate of aluminium may simply appear opaque to certain rays because these are not sufficiently powerful to set up an analogous secondary action: and at close quarters the apparently transmitted rays may much more nearly resemble the original. A. D.

1262. *Electric Charge of Radium Rays.* **P. Curie** and **Mme. P. Curie.** (Comptes Rendus, 130. pp. 647–650, March 5, 1900.)—The magnetically deflected rays of radium compounds resemble kathode rays rather than Röntgen rays, not only in the matter of magnetic deflection, but also in the fact that they convey a negative charge. This has been proved by the authors in various ways. On account of the complication introduced by the fact that the radiation imparts conductivity to the air or to any other surrounding gas, it was necessary to keep the electrode receiving the radiation sealed up in a non-conducting envelope, against one side of which the radium preparation was pressed. The preparation was contained in a thick-walled leaden box, and was covered with a piece of aluminium foil 0·01 mm. thick. Even after traversing this, and an ebonite layer 0·3 mm. thick, the rays conveyed a current of the order of 10^{-11} ampere through the galvanometer connected with the enclosed electrode. Conversely, when the radium preparation was embedded and the outer metallic envelope put to earth, an electrometer connected with the radium box showed a positive charge which is apparently maintained without loss, and would steadily rise if perfectly insulated. E. E. F.

1263. *Induced Radio-activity.* **E. Rutherford.** (Phil. Mag. 49. pp. 161–192, Feb., 1900.)—All thorium compounds examined produce radio-activity in all solid substances in their neighbourhood if the bodies are uncharged. With charged conductors the radio-activity is produced on the negatively charged bodies. In strong electric fields the radio-activity can be concentrated on the surface of thin wires. Thorium oxide is the most active of the thorium compounds in this respect, but loses its power if it is heated for several hours at a high temperature. The radiation excited is homogeneous and more penetrating than the radiations from thorium or uranium. It is confined to the surface of the substance, and is independent of whether the substance is a conductor or not, and of the nature of its surface. The intensity of the induced radiation falls off in geometrical progression with the time, decreasing to half value in about eleven hours. The decay of intensity is independent of the state of concentration of the radio-activity or the nature of the substance. With time of exposure the induced radio-activity at first increases nearly proportionally, but tends to a maximum value. The amount of radio-activity produced in a given time on a conductor depends on the

potential difference between the electrodes and tends to a constant value for large E.M.F.'s. The amount of radio-activity is independent of the pressure of the gas, except at low pressures, when the amount on the negatively charged conductor decreases with the pressure. The amount is not much affected whether the gas is H, air, or CO_2. No increase of weight has been observed by making a body radio-active. The radiation from a platinum wire is not much altered by placing the wire in a frame, in hot or cold water, or in nitric acid. HCl and H_2SO_4 rapidly remove the radio-activity from its surface. Discussion of three possible explanations; (*a*) a kind of phosphorescence excited by radiation from thorium; (*b*) deposition of the positively charged gaseous ions produced in the gas; (*c*) deposition of particles of a radio-active material emitted by thorium compounds. Of these (*a*) will not serve, and between (*b*) and (*c*) the evidence is not conclusive, though (*c*) seems somewhat the more tenable view. The power of exciting radio-activity in this way seems to be confined to thorium compounds. A. D.

1264. *Phosphorescence and Temperature.* **G. le Bon.** (Comptes Rendus, 130. pp. 891–894, April 2, 1900.)—The author has experimented on the phosphorescent power of four radio-active materials having barium bromide for base. All four discharged an electroscope when placed near it. Three of the samples possessed an intense phosphorescence without being exposed to light. The fourth appeared non-phosphorescent, but it became phosphorescent on being placed on a plate heated to 200°. If kept at this temperature it soon lost its phosphorescence. On cooling it did not phosphoresce, and only partially regained the power of phosphorescing under heat after some hours in darkness. It required two or three days to completely regain the power. The substances which phosphoresced at ordinary temperatures lost their phosphorescence when placed on the hot plate but rephosphoresced on cooling, and this cycle could be repeated indefinitely. The author attributes these phenomena to a series of chemical reactions which take place at different temperatures. He has experimented with other phosphorescent bodies in which the chemical changes are known, to obtain support for this hypothesis.
J. B. H.

REFERENCES.

1265. *Reference Points in Spectra.* **A. Perot** and **C. Fabry.** (Comptes Rendus, 130. pp. 492–495, Feb. 19, 1900.)—In continuation of their former work the authors have determined by their interferential spectrometer a series of standard wave-lengths from λ 4,300 to λ 6,700. The present paper also describes a recent improvement for more accurately gauging the distance between the interfering surfaces, and contains a list of eighteen standard lines in the spectra of mercury, zinc, copper, silver, sodium, and lithium. C. P. B.

1266. *Energy in Spectrum of a Black Body.* **F. Paschen.** (Preuss. Akad. Wiss. Berlin, S.ber. 53. pp. 959–976, 1899.)—In previous articles (see 1899, Abstracts Nos. 1348, 1482) the author has investigated the distribution of energy in the spectrum of a black body at temperatures from 100° to 450° C. The present article contains description of apparatus and experimental data extending the inquiry to about 1,300° C. C. P. B.

1267. *Propagation of Light.* **G. Sagnac.** (Journ. de Physique, 9. pp. 177–189, April, 1900).—An article dealing at length with the subjects referred to in Abstracts Nos. 48 and 614 (1900).

HEAT.

1268. *High Temperature Thermometer of Quartz.* **A. Dufour.** (Comptes Rendus, 130. pp. 775–776, March 19, 1900.)—The author describes a thermometer consisting of a quartz tube and bulb containing tin; temperatures between 240° and 580° can be measured with it. T. H. P.

1269. *Simple Apparatus for Expansion of Air.* **C. F. Adams.** (Phys. Rev. 10. pp. 178–179, March, 1900.)—This apparatus is designed to facilitate the attainment by elementary students of a good determination of the expansion coefficient of air at constant pressure. It consists of a glass U-tube of 3 or 4 mm. bore. The limb which contains the air is about 80 cm. long, and is closed at the end by a piece of glass fused into it. The other limb is about 50 cm. long and open at the end. The bend of the tube contains sulphuric acid to a depth of about 10 cm. Another glass tube is slid into the longer limb of the U-tube and dips into the acid. This tube serves as a plunger, and is used to adjust the level of the acid to the same height in each limb as ascertained by a sliding cross-piece. Temperatures between 10° and 50° C. are used in the experiments. Within these limits the vapour pressure of the acid is negligible and the use of acid instead of mercury insures the dryness of the air under examination. The U-tube is placed successively in water baths of various temperatures, the plunger and cross-piece being each time adjusted and the measurement of volume made on withdrawal from the bath. The significant figures of the results obtained by one class of students are as follows: 363, 364, 369, 368, 364, 371, 351, 366. E. H. B.

1270. *Fusion of Rubidium.* **M. Eckardt.** (Ann. d. Physik, 1. 4. pp. 790–792, April, 1900.)—Large quantities of rubidium and cæsium were prepared by a new process, and their change of volume during fusion was determined by means of a special paraffin dilatometer securing perfect protection against oxidation. The fusing-point of rubidium was found to be 37·80°. On melting, 1 gramme of rubidium was found to increase in volume by 0·01657 c.c. The corresponding expansion of cæsium was 0·01393 c.c. E. E. F.

1271. *Bunsen's Ice-Calorimeter.* **J. W. Mellor.** (Journ. Phys. Chem. 4. pp. 135–136, Feb., 1900.)—In order to exclude all air from the water-chamber, fill the chamber a third full with distilled water, attach the side tube of the calorimeter to a tube passing through the cork, and nearly to the bottom, of an ordinary distilling flask half filled with distilled water, the side neck of which is fitted to one end of a Liebig's condenser whose other end is connected to a water air-pump. Set the pump in action and heat both calorimeter and flask until the latter gives the characteristic "hammering" when shaken: the calorimeter will then become filled with air-free water on removing the flame that heats it. R. E. B.

1272. *New Thermo-Calorimeter.* **G. Massol.** (Comptes Rendus, 130. pp. 1126–1128, April 23, 1900.)—For the investigation of the specific heats of *superfused* bodies and of very concentrated saline solutions near their fusing-

and boiling-points Regnault's thermo-calorimeter is especially adapted, but its range is very limited. The author, therefore, provides an extra chamber at the top of the measuring-tube, as in Walferdin's thermometers, so that varying amounts of the measuring liquid may be employed; he replaces alcohol by sulphuric acid so that he may operate up to 300° C. instead of being limited to 50°, and instead of a cooling chamber surrounded by ice he employs any suitable constant-temperature stove. R. E. B.

1273. *Isothermals of Gaseous Mixtures.* **N. Quint.** (Phys. Zeitschr. 1. pp. 65–66, 1899. Communication from the Physical Laboratory of the University of Amsterdam.)—To test van der Waals' theory of the mixture of two bodies, mixtures of ethane and hydrochloric acid were examined, and the two gases were also examined separately. Among the results obtained it appears that the critical temperature of the mixture examined is 27·2°. Although, therefore, the critical temperatures of the pure substances are separated by some 20 degrees, the critical temperature of the mixture is found to be outside those of the two constituents. This result, which confirms similar results previously obtained, is in direct contradiction to Pawlewski's rule. E. E. F.

1274. *Thermo-dynamical Properties of Superheated Steam.* **J. H. Grindley.** (Roy. Soc., Proc. 66. pp. 79–85, March 8, 1900.)—In experiments on wire-drawing saturated steam the law of adiabatic expansion is assumed to hold during the flow, and is used in obtaining temperature results from wire-drawing calorimeters for the determination of the initial dryness of steam. If the assumption is correct, it appears, from the theory, that when the ratio of the lower to the higher pressure on opposite sides of the orifice is diminished below a certain value, the higher pressure being constant, the rate of discharge of the steam should be constant. For saturated steam this ratio is 0·5824. If the flow of steam be truly adiabatic this ratio giving maximum flow should be actually found by experiment; if some other value be found, the law of flow is not adiabatic. An experiment was made with an orifice drilled in a piece of thin brass, when it was found that the maximum discharge did not occur until the pressure ratio had fallen to 0·333—a value far below that indicating adiabatic flow. A later experiment was made with an orifice drilled in a glass plate, the experimental results showing a complete agreement with the theory of adiabatic flow.

Experiments were conducted with saturated steam at a known pressure and temperature in the steam chest, but at different degrees of wetness in different experiments. The maximum difference of temperature at any particular pressure in the wiredrawn steam which could be found to exist between experiments with different degrees of wetness was 0·85° F. Generally the difference could not be distinguished; if the dryness of the steam before passing the orifice had been altered by so little as 0·06 per cent., a difference of 1° F. should have been observed in the temperature of the wiredrawn steam. Between the limits of temperature obtained by wire-drawing saturated steam at temperatures varying from 240° to 380° F., the condition of a perfect gas was not obtained, even when the wiredrawing was continued to 3 or 4 lbs. per square inch absolute pressure. Between the same temperatures, and between pressures of 2·5 and 195 lbs. per square inch, the specific heat at constant pressure was found to increase with temperature, the mean specific heat at atmospheric pressure between the temperatures 230° and 246° being 0.4817, and between the temperatures 295° and 311° the mean

specific heat was 0.6482. The variation in the specific heat with the pressure is very small compared with the variation with temperature.

The specific heat K_p and the cooling effect $\delta\theta/\delta p$ or c are considered. The cooling effect c is found to be inversely proportional to $\tau^{3\cdot8}$, where τ is the absolute temperature. It is then shown that the formula $\frac{\delta}{\delta p}(K_p) = -\frac{\delta}{\delta\tau}(c\,K_p)$ is capable of strict proof. A. S.

1275. *Otto Gas Engines.* **L. Marchis.** (Comptes Rendus, 130. pp. 705–708, March 12, 1900.) *Theoretical Cycle of a Gas Engine.* **A. Witz.** (Comptes Rendus, 130. pp. 1118–1119, April 23, 1900.) *Gas Engines.* **L. Marchis.** (Comptes Rendus, 130. pp. 1246–1248, May 7, 1900.)—The efficiency is calculated for a series of operations not perfectly cyclical, which is really as follows, though in the paper described with less exactness : (1) The explosive mixture is admitted to the cylinder, as it alters volume from 0 to V, at the temperature t and at the pressure p of the atmosphere, which also acts on the outer face of the piston ; (2) it is then compressed adiabatically to volume v, attaining thereby the pressure P and temperature T ; (3) explosion then occurs adiabatically and isometrically, the pressure and temperature becoming P′ and T′ ; (4) adiabatic expansion to volume V follows, with fall of pressure and temperature to p' and t' ; (5) isometric change till the pressure becomes p next occurs, and (6) the exploded mixture is finally allowed to escape into the atmosphere, the volume of the cylinder being diminished to 0, while the outer face of the piston is again exposed to atmospheric pressure. Operations (2) and (4) at once give $A = k'(T' - t') - k(T - t)$ for the area of the cycle, where k and k' are the isometric specific heats of the mixture before and after explosion, and from operation (3) we have $k'(T' - T) = H$, where H is the heat given out on isometric explosion at T. The efficiency is then A/H [which, expressed in terms of the data, is

$$1 - a^{\kappa'-1} + \left\{k'(1 - a^{\kappa'-1}) - k(1 - a^{\kappa-1})\right\} T/H,$$

where $a = v/V$ and $T = ta^{1-\kappa}$, κ and κ' being the ratios of the isopiestic and isometric specific heats of the mixture before and after explosion], and, if we may take κ' and κ as approximately equal, and so $k' = k$, this becomes $1 - (t' - t)/(T' - T)$ [which is independent of H and equal to $1 - a^{\kappa-1}$]. Starting from this result Marchis adversely criticises the usual theory given for the Otto engine, in which he asserts that the assumption $p' = p$ is made. [The above notation is varied from that of the paper for greater symmetry.]

Witz denies that the assumption $p' = p$ is made, and states that in the usual theory operation (4) proceeds till the pressure falls to p (the temperature then being t'' and the volume V″), and that (6) follows, the efficiency then for $k' = k$ becoming $1 - \kappa(t'' - t)/(T' - T)$. [But this value requires the work done to be $k'(T' - t'') - k(T - t) - p(V'' - V)$; does not however condition (6) require the omission of the last of these terms, and give $1 - (t'' - t)/(T' - T)$ for the efficiency ?]

Marchis points out that Witz's criticism is off the point, as he considered engines of the Otto type only in which the adiabatic expansions and compressions are not different ; that there is nothing like a true cycle in the case of gas engines, and that Witz's formula for the efficiency cannot be general, though given as such. R. E. B.

ELECTRICITY.

THEORY AND ELECTROSTATICS.

1276. *Electron Theory of Metals.* **P. Drude.** (Ann. d. Physik, 1. 3. pp. 566–618, March, 1900.)—The author uses the term "ion" for the combination of electric particles and ponderable masses found in electrolytes, and he calls the particles probably concerned in metallic conduction "electrons" or "electric nuclei." He leaves it undecided whether an electron carries any ponderable mass along with it. It is not necessary to attribute ponderable mass to an electron in order to be able to attribute kinetic energy to its motion, and a certain inertia, as exhibited in the magnetic deviation of kathode rays and the optical qualities of metals. Since every moving electron represents an electric current, producing a certain number of magnetic lines of force in the surrounding ether, all forces tending to alter the direction and velocity of an electron must call forth opposing forces due to a change in the number of magnetic lines of force attached to the electron, or, in other words, due to the self-induction of the electron. Since the self-induction of a current of given strength is the greater the smaller the section in which it is concentrated, the apparent mass of an electron must depend upon its charge and upon its dimensions. The absence of a ponderable mass attached to the electron makes it possible to bring metallic and electrolytic conduction under the same theory. The assumption that the ratios of charge to mass in the positive and negative electrons respectively are two absolute constants in all metals is not in agreement with the optical behaviour of the latter. In gold and copper it is necessary to assume the presence of bound electrons, having a certain position of equilibrium in the body, and bound to the material particles. It is these bound electrons which play a part in optical processes. The author's theory differs from that of Riecke in the smaller number of unproved hypotheses, based as it is upon the laws of gases. Loschmidt's value for the number of molecules in 1 c.c. of a gas, and Thomson's value for the charge of an electron.

The author assumes the existence of any number of different kinds of electrons with various charges, each charge being, however, a multiple of a certain elementary charge. These freely movable electrons or "nuclei" are assumed to obey the kinetic theory of gases. That positive and negative nuclei do not coalesce to a neutral point, in spite of their mutual attraction, is attributed to their high kinetic energy, as in the case of a comet which never returns to the solar system. The ponderable atoms of a solid may also possess kinetic energy, but are bound to certain positions of equilibrium. Exceptions from Wiedemann's law of conductivities occur wherever the number of nuclei depends upon the temperature. From the deviation of a metal from that law the ratio of the conductivities of its two types of nuclei may be calculated. The author investigates the phenomena of contact electricity and thermo-electricity, both in liquids and solids, with the aid of his theory, and arrives at the conclusion that all galvano- and thermo-magnetic effects may be explained and calculated with its aid, as he intends to show in detail in two further communications. E. E. F.

1277. *Relation between Magnetic Field and Permeability.* **R. A. Fessenden.** (Phys. Rev. 10. pp. 1–88, Jan., and 88–115, Feb., 1900.)—In connection with his determination of the nature of the electromagnetic quantities the author was led to investigate the various suggested relations between μ and H, in the hope of thus finding the needed fourth equation [see 1900, Abstract No. 1278]. The relation proposed by Lamont and Frölich is—

$$1/\mu = a + b\,\mathrm{H}.$$

Kennelly's formula, proposed October, 1891, is—

$$1/(\mu - 1) = a + b\,\mathrm{H} = \nu_i.$$

The first is obviously incorrect for high values of induction, as it makes the total induction reach a limit, and Ewing's experiments show this is not the case. Kennelly's formula, on the other hand, has been confirmed by Steinmetz and again by the author in a research here detailed. The difference between the two is that Kennelly considers the induction contributed by the iron as separate and distinct from that contributed by the ether, in the same manner as, in Gladstone's law, we consider the refraction contributed by the matter as distinct from that contributed by the ether. There are thus two magnetic circuits in parallel: one, the intrinsic circuit, carrying a flux numerically equal to B — H; the other, the extrinsic circuit, carrying a flux numerically equal to H. As they both have the same difference of magnetic potential across them, the magnetic resistivity, or reluctivity, is, in the two cases, numerically H/(B — H) and H/H. Kennelly's law means that this intrinsic reluctivity, ν_i is given by the formula $a + b$ H, or that this intrinsic reluctivity varies as the space rate of drop of magnetic potential varies. The papers of Kennelly and Steinmetz showed an experimental agreement with the formula fairly close in all cases examined. Still the formula had been put forward as a purely empirical one and not as the expression of any physical law. The present author accordingly subjected it to a searching test. For this purpose he objects to the current experimental methods, whether with long wires or rings of the ordinary form, and describes the elaborate precautions taken in his own research on soft iron. This obeyed the formula with a maximum deviation of ¼ per cent., which was the maximum amount of experimental error. On reviewing the work of Gerosa and Funzi, of Steinmetz and of Silow, on iron, on the *non-magnetic* 10 per cent. amalgam of iron with permeability as low as 2, and on solutions of chloride of iron respectively, it is concluded that it is extremely probable that the law holds generally and that the following statements are justified. The relation between H and ν_i is given for all substances by the equations—

$$\nu_i = a + b\,\mathrm{H}, \text{ or } d\mathrm{B}_i / d\mathrm{H} = a\mathrm{B}_i^2 / \mathrm{H}^2,$$

where— $$\mathrm{B}_i = \mathrm{B} - \mathrm{H}.$$

The constant a is shown to have the nature of elasticity, and b is shown to have zero dimensions. Further—

$$\frac{b\eta}{a} = 0{\cdot}007 \text{ approximately,}$$

where η is the hysteresis loss per c.c. per cycle.

[The remainder of this paper is dealt with in Abstracts Nos. 1283, 1284, *1285, 1278,* and 1279 (1900).] **E. H. B**

[redacted]

1278. *Nature of Electromagnetic Quantities.* **R. A. Fessenden.** (Phys. Rev. 10. pp. 1–33, Jan., and 83–115, Feb., 1900.)—Following up the work of Rücker (Phil. Mag., Feb., 1889) and Williams (Phil. Mag., Sept., 1892), the present author, by use of dimensional formulæ, determines the nature or quality, of quantity of electricity, quantity of magnetism, dielectric constant and magnetic permeability. Let these physical quantities be denoted respectively by Q, P, κ, and μ; then it had been shown by Williams that, on making certain very natural assumptions, there were only two possible solutions. Of these, one makes μ a density and κ the reciprocal of an elasticity, while the other interchanges the natures of these two quantities. It is here pointed out that this ambiguity remained because some time back only three independent phenomena were known connecting the four unknown quantities. The author's experiments and his examination of the results of others have led him to formulate a fourth relation as follows: "For all magnetic substances the rate of variation of magnetisation with magnetising force is proportional to the square of the magnetic susceptibility." This relation is based on an equation originally proposed by Kennelly in 1891. The suggestion to search for a new relation between μ and H was derived from consideration of the three relations previously known, which may be expressed thus:—

$$Q/P = \kappa^{\frac{1}{2}}/\mu^{\frac{1}{2}} \qquad (1)$$
$$QP = ML^2/T \qquad (2)$$
$$\kappa^{\frac{1}{2}}\mu^{\frac{1}{2}} = T/L \qquad (3)$$

Of these three equations (1) is derived from Coulomb's law and its magnetic analogue; (2) is from Faraday's law, that the time rate of change of induction is a measure of the voltage, voltage multiplied by current giving power; while (3) is from Weber's law, that a circuit carrying a current is equivalent in its magnetic effect to a magnetic shell whose moment is equal to the area enclosed by the contour of the circuit. This third equation is known as Maxwell's.

A fourth relation was then written as follows:—

$$\kappa^{\frac{1}{2}}/\mu^{\frac{1}{2}} = Z \qquad (4)$$

and different dimensional values assigned to Z and the consequences discussed. Williams's result is then reached that either κ is a density and μ a compliancy, or *vice versâ*. The critical relation is then inferred, viz., "*Of κ and μ, the one which is a compliancy will be an inverse function of the corresponding force.*" This is the touchstone. It is known that the capacity of a condenser does not decrease with increased voltage, and equally well known that the *permeance* of a magnetic circuit does decrease with increase of *gilbertance* [*i.e.*, μ is known to decrease with increase of H]. It then remained to be proved that the rate of this change is that called for by the statement enunciated above. This being done, Z is shown to have the dimensions M/L^2T. On substitution of this value in (4) the solution follows, namely, that—

$$Q = M/T, \quad P = L^2, \quad \kappa = M/L^3, \quad \mu = LT^2/M.$$

Or in words, *the dielectric constant is of the nature density and the magnetic permeability is the reciprocal of an elasticity.* The author then adduces much corroborative evidence and discusses many incidental matters.

[The remainder of this paper is dealt with in Abstracts Nos. 1283, 1284, 1285, 1277, and 1279 (1900).] E. H. B.

1279. *Removal of 4π from Magnetic Equations.* **R. A. Fessenden.** (Phys. Rev. 10. pp. 1–83, Jan., and 83–115, Feb., 1900.)—The author discusses the removal of 4π without a change in the legal units [see also Abstract No. 648 (1900)]. The following changes are introduced. The unit quantity of magnetism is made equal to the present magnetic line, and the unit difference of magnetic potential to the ampere turn. No change is made in the coulomb, ampere, volt, ohm, farad, joule, or watt. Unit quantity of magnetism is thus made $1/4\pi$ times as large as before. Difference of magnetic potential is made 4π times as large as before. In place of dielectric constant and permeability the somewhat different quantities *capity* and *permity* are suggested. The permity of a vacuum would then be 4π, whereas the permeability for vacuo is now unity. The value of the dielectric constant would remain the same as before, only as we should be dealing with a different thing, viz., the ratio of quantity to potential gradient instead of flux to potential gradient, we should speak of the capity of a vacuum as being $1/4\pi$, where before we spoke of the dielectric constant of a vacuum as unity. On the new system there is no use for "flux" as distinct from "quantity." This, it is claimed, simplifies matters by rendering unnecessary 46 quantities now in use.

[Other parts of this paper are dealt with in Abstracts Nos. 1283, 1284, 1285, 1277, and 1278 (1900).] E. H. B.

1280. *Rotations in an Electrostatic Field.* **L. Graetz.** (Ann. d. Physik, 1. 3. pp. 530–541, March, 1900.)—The author produces Quincke's rotations in a constant electric field, not by suspending bodies in it, but by mounting spheres of sulphur, ebonite, or paraffin on a needle-point, so that they are capable of continuous rotation. Experiments made in this manner show that the explanation of these rotations on the hypothesis of a repulsion of the charged portions of the rotating body by the similarly charged electrodes applies not only qualitatively but quantitatively. Hence the rate of rotation may serve the purpose of determining the conductivity of very bad conductors and its variation under varying conditions. The author applied this method to the measurement of the conductivity of air ionised by Röntgen rays, and he found that in liquids also, like benzol and ether, an increase of conductivity due to the rays could be traced. E. E. F.

1281. *Dissipation of an Electric Charge in Air.* **J. Elster** and **H. Geitel.** (Phys. Zeitschr. 1. pp. 11–14, 1899.)—The presence of certain bodies, such as a piece of slowly oxidising phosphorus, is known to impart to ordinary air a certain electric conductivity. Röntgen and Becquerel rays possess the same property; but it has not been established experimentally whether ordinary air in the open possesses an electric conductivity or not. The object of this investigation was to answer this question.

Suppose a charged body, placed in the open air, had its potential indicated on an electrometer. The loss of potential in a certain time when the body is connected to the electrometer gives a measure of the dissipation of charge provided we know the corrections to be applied for leakage, &c.

The electrometer used is a gold-leaf electroscope of special construction. The leaves are supported on a metal pillar fixed to ebonite insulation at the bottom of the glass case. This metal pillar carries a ball at its upper end which is bored out conically on the top to receive the end of the support for

the electrified body, so that the body is entirely supported by the electrometer. The glass case has a hole in the top which clears the support.

The electrified body consists of a hollow metal cylinder with closed ends supported on a metal rod coaxial with the cylinder. The free end of this rod is turned to fit the conical hole in the top of the electrometer pillar.

The experimental readings taken are: first, the rate of fall of potential (or collapse of the leaves) with the cylinder in position; second, the rate of fall of potential without the cylinder; and third, the ratio of the capacity of the electroscope alone to the capacity of the electroscope and cylinder together. This last is obtained by charging the electroscope alone, then by means of an insulated handle placing the cylinder in position on the electroscope and noting the immediate fall of potential. Suppose in the first experiment the potential falls from V_0 to V_1 in time t, and in the second it falls from V_0' to V' in time t'; then the electricity lost by the cylinder during the experiment is given by—

$$e = \frac{1}{t} \log \frac{V_0}{V_1} - \frac{n}{t'} \log \frac{V_0'}{V'}$$

where n is the ratio of the capacities.

The results of the experiments the authors propose to give in another paper. The dissipation is not always the same, but alters with the meteorological conditions and also with the sign of electrification. At mountain-tops in clear weather the loss of negative is much greater than the loss of positive. In cloudy weather both sink to a minimum. In the neighbourhood of waterfalls positive is dissipated more quickly than negative. The results agree with the assumption that ordinary air contains equal numbers of positively and negatively electrified particles. The negatively electrified particles would slowly discharge a positively electrified body, and *vice versâ*. At mountain-tops the density of the earth's negative charge is greatest, and so there is a preponderance of positively electrified particles in the air which account for the increased rate of discharge of negative electricity. In the neighbourhood of waterfalls the conditions are reversed. In cloudy weather the condenser action of the clouds alters the conditions.

The loss in ten minutes in a room of 65 cubic metres capacity was doubled as soon as 800 grammes of Uranium-pitch was brought into the room to a distance of 2 or 3 m. from the cylinder. A draught from the neighbouring room containing the so-called Radium and Polonium preparations produces remarkable increase in the dissipation of the charge. J. B. H.

1282. *Electrical Effects on Evaporation of Sodium in Air and other Gases.* **W. C. Henderson.** (Roy. Soc., Proc. 66. pp. 183–186, April 4, 1900.)—The experiments made on the evaporation of fused sodium lead to the conclusion that no electrification can be detected unless oxidation is going on. Thus electrification was detected before fusion of the sodium if air was present, but not detected at all when coal-gas was present to the exclusion of the air. E. H. B.

DISCHARGE AND OSCILLATIONS.

1283. *Gas Currents in Incandescent Lamps.* **J. Stark.** (Elektrotechn. Zeitschr. 21. pp. 151–152, Feb. 22, 1900.)—The author discusses the various theories advanced to account for the deposit of carbon on the inner walls of incandescent lamps in the course of time. Moissan's hypothesis of a slow

evaporation of the carbon of the filament is placed in doubt by the fact that the deposit does not depend upon the degree of exhaustion. Berliner's idea that gases are occluded in the filament and escape with explosive rapidity as soon as incandescence sets in is invalidated by the observation that the deposit is the same in continuously glowing lamps and in those which are often relighted. The author attributes the disintegration of the carbon to vagrant currents between various parts of the carbon filament, which traverse the intervening gas as in a Crookes tube. These vagrant currents can be placed in evidence by probes, but they are often made evident to the eye by an "aureole" between the arms of the filament which is nothing but the positive glow of a gaseous discharge. The internal currents are the stronger the greater the difference of potential between successive portions of the filament —*i.e.*, the higher the voltage of the circuit. The disintegration of the carbon is strongest at the kathode part, which turns rough very soon and wears through quickly where continuous currents are used. E. E. F.

1284. *Influence of Iron Cores on Condenser Discharges.* **G. A. Hemsalech.** (Comptes Rendus, 130. pp. 898–900, April 2, 1900.)—In the outer circuit of a condenser a self-induction is inserted, together with a vacuum and a spark-gap. The condenser is connected in parallel with an induction coil and a Wimshurst machine. The resulting discharge is of an oscillating character, and the polarity of the electrodes in the vacuum tube cannot be distinguished owing to the rapidity of the reversals. Its aspect is not changed by reversing the induction coil. If now an iron core is gradually introduced into the inductance coil, the oscillations are diminished and finally disappear. The process is clearly indicated by the aspect of the vacuum tube. The poles are gradually differentiated and establish themselves definitely at each end of the tube. This polarity is reversed by reversing the induction coil. The same transformation of the discharge may be brought about by inserting a water resistance. E. E. F.

1285. *Spark Potentials.* **J. E. Almy.** (Ann. d. Physik, 1. 3. pp. 508–529, March, 1900.)—The author determines the variation of spark potentials with the distance in various solid and liquid dielectrics, including glass, mica, quartz, paraffin, ebonite, turpentine, petroleum, xylol, and benzol. In all these substances the electric strength decreases with increasing thickness. The spark potential required for piercing 1 mm. of each of these substances is: Glass, 83·5; mica, 1890; paraffin, 375; turpentine, 161; petroleum, 212; xylol, 174; benzol, 194 c.g.s. units. The last figure is, however, doubtful. E. E. F.

1286. *Electric Arc between Metals.* **L. Arons.** (Ann. d. Physik, 1. 4. pp. 700–718, April, 1900.)—For the study of the electric arc as influenced by the nature of the surrounding gas, metallic electrodes are to be preferred to carbon electrodes, as their composition is better defined and they do not give out the great quantities of strange gases which render experiments in different gases worthless in the case of carbon electrodes. The gases experimented with were nitrogen and hydrogen. In nitrogen, arcs were obtained between aluminium, cadmium, copper, iron, magnesium, platinum, and brass electrodes. Tin melted at once, and between silver electrodes no arc could be made to play in an atmosphere of nitrogen. This fact is all the more remarkable as silver yields a particularly brilliant arc in air. It is evidently connected with the difference of chemical affinity between the metal and the gas in the two cases. The author found that nitrides are formed of all the other metals,

but not of silver. Aluminium electrodes are covered with a greyish-black crust, whose chemical properties identify it with the nitride discovered by Mallet. Brass electrodes acquire a copper colour, owing to the greater consumption of zinc. Copper and aluminium, which in nitrogen give very beautiful arcs, give practically none in hydrogen. Platinum, silver, iron, and lead require very strong currents. The best hydrogen arcs are obtained with cadmium, zinc, and magnesium. E. E. F.

1287. *Electric Discharge in Gases and the Heat Produced.* **W. Wien.** (Phys. Zeitschr. 1. pp. 10–11, 1899.)—The electric discharge in gases takes place partly by means of material particles which, moving with great velocities, are accelerated at first positively, then, by impacts against other particles, negatively. These conditions must give rise to a radiation of electromagnetic energy. The present investigation was undertaken to see whether this energy could be measured by the difference between the electric energy supplied to vacuum tubes and the heat produced in the tubes. The E.M.F. at the electrodes and the current were measured by volt and ampere meters, and the heat produced was measured by a Bunsen calorimeter. The following table, in which some of the results are reproduced, shows that within the limits of experimental error the electrical and heat energy are equal :—

E.M.F. volts.	Current amperes × 10^6.	Calories × 10^3 calculated.	Calories × 10^3 observed.
368	1,085	95·4	94·9
585	1,152	147	149
562	5,682	763	771
682	4,894	716	718
888	2,026	406	411
982	1,781	885	893
1,650	810	122	125

J. B. H.

1288. *Magnetisation of Vacuum Tubes.* **R. Dongier.** (Comptes Rendus, 130. pp. 650–653, March 5, 1900.)—The author compares the new magneto-optic effect observed by him [see 1900, Abstract No. 826] with that observed by Egoroff and Georgiewsky in the case of flame spectra. The former differs according to the angle between the ray and the magnet vector. E. E. F.

1289. *Magnetic Effect on Vacuum Tubes.* **N. Egoroff** and **N. Georgiewsky.** (Comptes Rendus, 130. pp. 900–901, April 2, 1900.)—In vacuum tubes containing hydrogen, helium, or iodine, placed vertically in an equatorial plane between the poles of an electromagnet, a partial polarisation of the emitted rays is only observed in one direction of the field, but not when the field is reversed. Partial polarisation is also observed in an axial direction along the tube, and then it is independent of the direction of the field. The polarisation phenomena are such as can be explained by the reflection and refraction of the glass walls of the tube, and the magnetic effect upon the polarisation is secondary, being due to the bending of the discharge under the influence of the magnetisation, which leads to modified optical conditions. The phenomena are the same in the case of a small flame burning in a similar tube. E. E. F.

1290. *Electrolytic Convection in Vacuum Tubes.* **H. Morris-Airey.** (Phil. Mag. 49. pp. 307–309, March, 1900.)—J. J. Thomson has described a case of apparent electrolytic convection of chlorine through hydrogen. A small

quantity of chlorine is introduced into a capillary tube filled with hydrogen at a low pressure, and a discharge from an induction coil is sent through the tube. On examining the tube with a spectroscope the chlorine is seen only at the anode, and on reversing the current the chlorine appears at the new anode, and so on as often as the current is reversed. The most obvious explanation lies in electrolytic convection, but it is not at all certain that the chlorine does not pervade the whole tube, and is only discovered at the anode on account of the high temperature which exists there. To decide between the two views, the author attached two vacuum tubes to each other, end to end, and first used the anode of the one and the kathode of the other as electrodes, neglecting the two electrodes in the middle. If the electrolytic convection hypothesis were correct, a spectroscopic examination should reveal the existence of chlorine only in that tube whose extreme electrode was used as an anode. On separating the two tubes, however, the author found that the chlorine lines had the same intensity in both. E. E. F.

1291. *Electrolytic Convection in Vacuum Tubes.* J. J. **Thomson.** (Phil. Mag. 49. p. 404, April, 1900.)—The author does not think that Morris-Airey's "crucial" experiment [see preceding Abstract] disposes of his theory of electrolytic convection in vacuum tubes. That chlorine should be found in all parts of the tube is inevitable when as large amounts of chlorine are mixed with the hydrogen as in Morris-Airey's experiment. The increase of the partial pressure of the chlorine must accelerate its diffusion throughout the tube. In the author's original experiment a very small quantity of chlorine was mixed with the hydrogen, and the effects observed were not merely the presence of the chlorine lines at the anode and their absence at the kathode when the current was steady, but it was found that on reversing the current, so that the old anode became the kathode, the chlorine lines at first flashed out brightly at the new *kathode* and were faint at the anode. Then there was a short interval, during which they were faint at both electrodes, and finally they became bright at the new anode and invisible at the kathode. This seems a very complete proof of the transport of chlorine to the anode, and of the electrolysis of gases in a vacuum tube. E. E. F.

1292. *Electric Discharge through Argon and Helium.* R. J. **Strutt.** (Phil. Mag. 49. pp. 293–307, March, 1900.)—The difference of potential between the surface of the kathode and the outside of the negative glow is a constant, independent of the current and the pressure, provided there is no chemical action on the kathode and the glow does not cover the whole of the kathode. This constant potential difference is known as the kathode fall of potential. The author has measured it in helium and argon. In ordinary gases it is 300 volts. In helium it is 226, while in argon it is 167 volts. The case of argon presents peculiar difficulties, inasmuch as the positive column insists on curling round the kathode—a phenomenon which does not seem to have been observed in any other gas. The difficulty was finally overcome by giving the kathode the shape of a disc which nearly filled up the cross-section of the tube. An interesting investigation was that of the conductivity of helium under the influence of Röntgen rays. Experiments in which the conductivity of air and helium respectively was brought to a maximum by strong Röntgen-ray ionisation showed that the rate at which ions are produced in helium is about half that at which they are produced in air. The expenditure of energy in this process is also less. The ions of all monatomic gases are probably split up into something smaller. E. E. F.

1293. *Velocity of Electric Waves in Bitumen with and without Wires.* **C. Gutton.** (Comptes Rendus, 130. pp. 894–897, April 2, 1900.)—Following a method analogous to that adopted for establishing the equality of velocities of free and guided electric waves in air [see Abstracts Nos. 1498 (1899), and 1077 (1900)], the author now finds that this equality holds when the electric waves with and without wires are propagated in bitumen. E. H. B.

1294. *Masses of Ions.* **J. J. Thomson.** (Phil. Mag. 48. pp. 547–567, Dec., 1899. Paper read before the British Association at Dover.)—This paper contains an account of measurements of m/e and e for the negative electrification dissipated by ultra-violet light, and also of m/e for the negative electrification produced by an incandescent carbon filament in an atmosphere of hydrogen. They lead to the result that the value of m/e in the case of ultra-violet light, and also in that of the carbon filament, is the same as for the kathode rays ; and that in the case of ultra-violet light e is the same in magnitude as the charge carried by the hydrogen atom in the electrolysis of solutions. In this case, therefore, we have clear proof that the ions have a very much smaller mass than ordinary atoms, so that in the convection of negative electricity at low pressures we have something smaller even than the atom, something which involves the splitting up of the atom, inasmuch as we have taken from it a part, though only a small one, of its mass.

The method of determining the value of m/e for the ions carrying the negative electrification produced by the ultra-violet light is based upon the fact that the rate of escape of the negative electrification at low pressures is much diminished by magnetic force if the lines of magnetic force are at right angles to the lines of electric force. The charge on the ion produced by the action of ultra-violet light on a zinc plate was determined by the author's method of measuring the charge on the ions produced by the action of Röntgen rays on a gas.

The results suggest that the ionisation of a gas consists in the detachment from the atom of a negative ion, this negative ion being the same for all gases, while the mass of the ion is only a small fraction of the mass of an atom of hydrogen. This negative ion is not improbably the fundamental quantity in terms of which all electrical processes can be expressed. For its mass and its charge are invariable, independent both of the processes by which electrification is produced and of the gas from which the ions are set free. It thus possesses the characteristics of a fundamental conception in electricity. The author sketches an electrical theory of which this conception forms the basis. The atom is regarded as containing a large number of similar bodies, which he calls "corpuscles." The mass of a corpuscle is the mass of a negative ion in a gas at low pressure, *i.e.*, about 3×10^{-26} grammes. In the normal atom this assemblage of corpuscles forms a system which is electrically neutral. The electrification of a gas may be regarded as due to the splitting up of some of the atoms of the gas, resulting in the detachment of a corpuscle from some of the atoms. The remainder of the atom forms the positive ion, and is of course of much greater mass. An atom might be split up indefinitely but for the fact that each detachment of a corpuscle increases the free positive charge of the remainder, and so increases the force of cohesion. The mass of the negative ion is about 1/500th part of that of the hydrogen atom. E. E. F.

1295. *De-coherence of Carbon.* **T. Tommasina.** (Comptes Rendus, 130. pp. 904–905, 1900.)—The author has discovered a variety of carbon which,

when used in a coherer, automatically loses its coherence as soon as the electric waves cease to impinge upon it. The carbon powder used is that of the microphones of the Swiss telephone stations. It is enclosed in a little box of ebonite and mica, and two German-silver wires lead into it, with their ends 1 mm. apart. The coherer thus constructed is introduced into a telephone box and inserted in the circuit of the telephone magnet. The impact of a wave is indicated by a tick in the telephone. Besides the automatic decoherence, the new apparatus has the advantage of greater durability on account of the stable nature of carbon. E. E. F.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1296. *Insulation Tests.* **W. E. Ayrton** and **T. Mather.** (Phil. Mag. 49. pp. 343–347, April, 1900.)—The guard-wire as originally arranged by W. A. Price was applied near the ends of the cable under test; it was intended to eliminate errors due to end leakage. The authors now use the guard-wire to eliminate leakages of all kinds from the leads. A concentric cable is employed as the lead, the "inner" conductor of which is connected to the conductor of the cable under test, while the "outer" acts as a continuous guard-wire. The "outer" is connected to some point between the battery and galvanometer. It is shown that the guard-wire principle can further be applied to determine whether a cable is faulty throughout, or whether it contains one or more faults in definite positions. Also, by employing two drums, faults in braided and other unsheathed cables can be localised by the use of a guard-wire. In making measurements with the guard-wire, it should be connected as near the braiding as is consistent with the condition that the resistance between the guard-wire and braiding is high compared to the battery resistance. The above remarks refer to the direct-deflection method, but the authors show that accuracy can also be obtained with the "loss of charge" method, by the use of a guard-wire. In this case the potential of the guard-wire is caused to fall at the same rate as that of the conductor of the cable under test, so that no electricity passes between them, and there is no surface leakage. R. A.

1297. *Dielectric Constant of Hydrogen Peroxide.* **H. T. Calvert.** (Ann. d. Physik, 1. 3. pp. 483–485, March, 1900.)—The dielectric constant of hydrogen peroxide is interesting to determine on account of Bruehl's speculation concerning the tetravalence of oxygen. The author employed an aqueous solution of the pure dioxide of density 1·144, and determined its dielectric constant by the method of electric waves. The constant found was 84·7 at 18°. Assuming the density of the pure dioxide to be 1·5, and the law of mixtures to hold good, the dielectric constant of pure H_2O_2 comes out as 92·8. It shows no anomalous absorption, and that circumstance, together with the fact that its dielectric constant is greater than that of water, is in agreement with the predictions of Bruehl, who expected an abnormally high dielectric constant on account of the existence of unsatisfied valencies. E. E. F.

1298. *Measurement of Capacity.* **R. Wachsmuth** and **K. Bergwitz.** (Phys. Zeitschr. 1. pp. 7–8, 1899.)—This paper gives an account of an attempt to measure capacity, using the double refraction of carbon disulphide when in an electric field. Two exactly equal condensers of two plates each are placed in carbon disulphide baths, and a beam of plane polarised light passed in succession between the plates of the two condensers. The two condensers are connected in parallel, and subjected to the same source of alternating

[redacted]

E.M.F. If the plane of polarisation makes 45° with the plates of each condenser, the plates of the one condenser being perpendicular to the plates of the other, then no rotation of the plane of polarisation takes place. If a small condenser is added to one side of the circuit, however, a difference of phase is introduced, and there is no longer darkness in the crossed Nichols. By introducing a variable capacity in the other branch, darkness can be again produced when the capacities are equalised. Such is the method here used. For small capacities up to 150 electrostatic units an accuracy of about 0·1 per cent. is obtained.

For large capacities a special method is necessary. The large capacity is introduced in the one branch as before, but with a small capacity in series with it. The capacity is then given by $C_x = C_v C_m / (C_v - C_m)$, where C_v is the capacity of the small condenser and C_m the balancing capacity. Since $C_v - C_m$ is always a small quantity, the variable condenser must be very accurate. Experiments gave a maximum difference of 10 per cent. between measurements of capacity by this method and by the ballistic. J. B. H.

1299. *Thermo-magnetic Currents.* **G. Moreau.** (Comptes Rendus, 130. pp. 412–414, Feb. 12, 1900.)—The relation—

$$K = \frac{\sigma c}{\rho}$$

established independently by Voigt and by the author between the coefficients of the Hall effect c and the Nernst effect K, the specific heat of electricity σ and the specific resistance ρ, required verification by the determination of all these constants in the same specimen. The author has made observations at different temperatures on iron, steel, cobalt, and nickel, all metals for which σ and ρ vary slightly under the influence of the magnetic field. In all these metals the above formula is verified for temperatures between 0° and 60°. In the case of cobalt, the ratio $\frac{c}{K}$ is not changed by tempering, though both K and c are altered considerably. As usual, the variations of K follow those of c, the Hall effect being the fundamental phenomenon. The latter is considerably influenced by the molecular condition of the plate, and is in fact due, as the author believes, to a deformation of the plate under the influence of the magnetic field. This would account for the great differences between the results of individual observers. E. E. F.

1300. *Electrolytic Conductivity and Internal Friction of Salt Solutions.* **P. Massoulier.** (Comptes Rendus, 130. pp. 773–775, March 19, 1900.) —The variations in electrical resistance and internal friction of copper sulphate solutions caused by replacing part of the aqueous solvent by glycerine are in the same direction and of the same order of magnitude, but not proportional. The conductivity depends not only on the internal friction but also on the degree of ionisation, which varies with the temperature and also with the nature of the solvent. T. H. P.

1301. *Resistance of Bismuth in Magnetic Field.* **W. Eichhorn.** (Phys. Zeitschr. 1. pp. 81–88, 1899.)—The author compares the resistance of bismuth in a constant and in a varying magnetic field with a view to discover the existence of hysteresis in the increase of resistance due to increase of field strength. A bismuth spiral connected in one arm of a Wheatstone bridge was mounted on a disc capable of rotation between the poles of an electro-

magnet. A second disc on the same axis completed the battery circuit for an instant during the passage of the bismuth between the poles; the two discs being relatively adjustable, contact could be made while the bismuth was entering the field or while leaving it.

Omitting details of the experiments and the corrections applied, the results are as follows :—

The bismuth while entering the field shows a less increase of resistance than in a constant field of the same average strength, but shows a greater increase while leaving the field.

With increasing velocity of rotation the resistance diminishes to a minimum value when the bismuth is entering the field, and increases to a maximum when leaving it.

The minimum value was reached in increasing the field from 0 to 8,900 lines in about 0·02 secs. The difference of increase of resistance amounted to about 2·5 per cent. The author considers that these results point to a time-lag of the variation of resistance after the field variation. G. H. B.

1302. *Condenser in Induction Coil.* **K. R. Johnson.** (Phil. Mag. 49. pp. 216–220, Feb., 1900.)—Referring to Mizuno's paper [see 1898, Abstract No. 1252] the author explains the results. If the condenser is inserted across the interrupter in the primary circuit, the extra current darts into the condenser; and if the maximum of the potential-difference in the condenser is very great, a spark takes place in the interrupter, and thus the oscillations in the circuit are diminished by the spark. If the capacity of the condenser is very large, the maximum of potential difference in the condenser and the interrupter is small and unable to make a spark. Thus, the efficiency of the induction-coil is greatly increased by increasing the capacity a little, so long as the discharge by spark at the interrupter diminishes; when the spark is entirely suppressed, the efficiency of the induction-coil is greatest and the secondary spark-length a maximum. The capacity of the primary condenser being further increased, the efficiency of the induction-coil is diminished, for the reason that the maximum potential difference in the condenser is diminished, and, of course, so is the intensity of the current. Mathematical developments and tables of calculated and observed values of spark-length are given. A. D.

1303. *Three-Phase Wattmeter Connections.* **R. Arno.** (Écl. Électr. 22. pp. 379–384, March 10, 1900. Paper read before the first Congress of Italian Electricians at Como, Sept. 19, 1899.)—A description of the different methods by which a wattmeter or watt-hour meter can be connected to measure the power of a symmetrically loaded three-phase circuit on inductive load. The power factor of the load can also be determined from wattmeter readings alone. By connecting the thin coil across the terminals of the circuit containing the main coil, the value of $EC \cos \phi$ is found. By connecting the thin coil across the other two terminals of the star, a value is obtained for $\sqrt{3}\, EC \sin \phi$. Hence $\cos \phi$ can be calculated. L. B.

1304. *Wave-Current Generators.* **C. Heinke.** (Ann. d. Physik, 1. 2. pp. 326–351, Feb., and 3. pp. 441–461, March, 1900.)—The author distinguishes two classes of wave-currents. One type is due to periodically varying electromotive forces, the other to periodically varying resistances. The latter may be divided into mechanical, electrolytic, and gaseous resistances, the first two being usually described as interrupters. All wave-current generators of automatic character, *i.e.*, those actuated by the current itself, especially the

electrolytic and gaseous ones, require an E.M.F. capable of yielding a certain "saturation current." A further increase of E.M.F. only influences the number of waves per unit of time, but not the practically constant saturation current, nor the density of the latter in the effective cross-section. E. E. F.

1305. *Influence of Temperature, Pressure, Used Solutions and Size of Anodes on Silver Voltameters.* **J. F. Merrill.** (Phys. Rev. 10. pp. 167-174, March, 1900.)—No change in the weight of silver deposited is produced by increasing the air pressure to 100 atmospheres. Further, if the solutions are previously boiled the weight of the deposit is the same at 0° and 90° C. If the electrolytic solutions have been much used, however, there is a marked increase in the weight of silver deposited, which may be as great as 0·17 per cent. The size of the anode has no influence on the deposit, but a slight increase in weight was found on comparing an old kathode-dish with dull surface, with a new, bright dish. T. M. L.

1306. *Wattmeter Correction for Alternating Currents.* **T. des Coudres.** (Phys. Zeitschr. 1. pp. 76–77, 1899.)—The correcting factor for a wattmeter is $\frac{1+\tan^2\phi}{1+\tan\theta\tan\phi}$, where θ is the lag in the circuit under measurement and ϕ is the lag in the shunt coil of the wattmeter. When, as is generally the case, θ is unknown, the correction cannot be applied.

The author proposes to shunt the main current winding of the wattmeter by an inductionless resistance of value R, such that $\frac{L_2}{R_2}=\frac{L_1}{R_1+R}$, where L_1, L_2, and R_1, R_2 are the self-induction coefficients and resistances of the main and shunt wattmeter coils respectively. The correcting factor then is $1/\cos^2\phi.\left(1-\tan\phi\frac{W_1}{2\pi n L_1}\right)$, or approximately $\frac{1}{\cos^2\phi}$. G. H. B.

1307. *Mirror Galvanometer.* **W. Thiermann.** (Elektrotechn. Zeitschr. 21. pp. 211–214, March 15, 1900.)—This instrument is a special form of potentiometer which is in use in the testing-room of the Electrotechnical Institute of the Hanover Hochschule for measuring pressures ranging from 750 down to 0·0007 V. It consists of a mirror galvanometer with telescope for reading the deflections, a dial resistance with eleven resistances, and a standard cell. The main feature of the instrument is the provision of means for adjusting the position of the scale. This is effected by mounting it on a carriage capable of being adjusted along two horizontal guide-rods by means of nut and leading screw, these guide-rods being mounted on a second carriage which is itself adjustable along two vertical guide-rods on a tripod stand, by means of another leading screw. C. K. F.

ALTERNATING CURRENTS AND MAGNETISM.

1308. *Capacity of Symmetrical Systems of Conductors when subjected to Polyphase P.D.'s.* **C. E. Guye.** (Comptes Rendus, 130. pp. 711–713, March 12, 1900.)—The capacity of a conductor is, by definition, the ratio of its charge to its potential when all the other conductors in the neighbourhood are at zero potential. If the potential of one or more of the neighbouring conductors is not zero, and is made to vary, then the ratio of the charge to the potential of the first conductor is no longer constant in the general case. But in the

special case of a symmetrical system of conductors, consisting of a number of parallel cylindrical conductors symmetrically arranged round an axis and enclosed in a hollow cylindrical conducting sheath, and subjected to polyphase potentials (there being as many phases as there are conductors), the author shows that the ratio of the instantaneous charge to the instantaneous potential of any one conductor is constant. Hence the "capacity" of a conductor in such an armoured polyphase transmission line acquires a perfectly definite meaning, and this quantity if known enables us at once to calculate the "condenser" current. The same result will hold for an overhead system of symmetrically arranged conductors, provided the distances apart of the conductors are negligible in comparison with their distance from the earth's surface. A. H.

1309. *Foucault Currents due to very Rapid Oscillations.* **I. Klemenčič.** (Phys. Zeitschr. 1. pp. 83–84, 1899.)—A high-frequency alternating current was maintained in a solenoid by Leyden jars charged by an induction coil with Wehnelt interrupter. The heating due to Foucault currents was measured in the mercury bulbs of various thermometers, and in iron wires enclosed in alcohol thermometers. The heating was considerably greater in the smaller mercury bulbs and in the thinner wires, as might be expected from the skin-effect of the rapidly alternating current. G. H. B.

1310. *Carrying Strength of Electromagnets.* **Boy de la Tour.** (Ind. Élect. 9. pp. 10–12, Jan. 10, 1900.)—Consider an electromagnet and carry it through the following cycle of operations :—(1) Pass a current through the coils and let the maximum value of the current be $I_0 = \frac{E_0}{R}$. (2) Apply on the keeper a pull of F dynes so that the magnetic circuit is elongated by a small quantity dl in a small time dt. This produces an induced E.M.F. due to the diminution of the flux. (3) Short-circuit the windings so that the flux disappears. On applying an E.M.F. the rise of current in the coils is given by—

$$E_0 - N\frac{d\phi}{dt} = Ri,$$

where N is the number of turns on the magnet, ϕ the flux through the core, and i the instantaneous value of the current.

The energy of the magnetic field is given by the expression—

$$\int_0^\infty N\frac{d\phi}{dt}\cdot i\,dt = N\int_0^\infty i\,d\phi$$

On applying to the keeper a force F it is displaced parallel to itself through a distance dl in a time dt. During this interval of time there is induced an E.M.F., $N\frac{d\phi}{dt}$, and the flux Φ_0 is diminished by a quantity $d\phi$. The diminution of energy during this period is—

$$NI_0 d\phi - \frac{\Phi_0 - d\phi}{2}.N\,di.$$

The energy supplied by the external source is—

$$\left(E_0 - N\frac{d\phi}{dt}\right)I_0 dt.$$

Also the work done on the keeper is $\mathrm{F}dl$, and that dissipated in heat is—

$$\mathrm{I}_0^2\mathrm{R}dl = \mathrm{E}_0\mathrm{I}_0 dl.$$

When the coil is short-circuited the energy returned to the source is—

$$\mathrm{N}\int_0^{\Phi_0} id\phi - \mathrm{NI}_0 d\phi + \mathrm{N}\frac{\Phi_0 - d\phi}{2}di.$$

Equating the energy supplied to the magnet to that which it restores, we get—

$$\mathrm{N}\int_0^{\Phi_0} id\phi + \left(\mathrm{E}_0 - \mathrm{N}\frac{d\phi}{dt}\right)\mathrm{I}_0 dt + \mathrm{F}dl$$

$$= \mathrm{E}_0\mathrm{I}_0 dt + \mathrm{N}\int_0^{\Phi_0} id\phi - \mathrm{NI}_0 d\phi + \mathrm{N}\frac{\Phi_0 - d\phi}{2}di,$$

or—

$$\mathrm{F}dl = \mathrm{N}\frac{\Phi_0}{2}di.$$

But—

$$\Phi_1 = \Phi_0 - d\phi = 4\pi\mathrm{N}di.\frac{\mathrm{S}}{2dl}$$

where S is the cross-section of the magnet pole thus—

$$di = \frac{\Phi_0 - d\phi}{4\pi\,\mathrm{NS}}.2dl,$$

therefore—

$$\mathrm{F}dl = \frac{\mathrm{N}\Phi_0(\Phi_0 - d\phi)}{4\pi\,\mathrm{NS}}dl.$$

And putting $\mathrm{BS} = \Phi_0$, where B is the induction, we finally obtain the result—

$$\mathrm{F} = \frac{\mathrm{B}^2\mathrm{S}}{4\pi}.$$

W. G. R.

1311. *Torsional Elasticity of Rods and Magnetisation.* **J. S. Stevens.** (Phys. Rev. 10. pp. 161–166, March, 1900.)—This is the continuation of a former paper [see 1900, Abstract No. 202] on the effect of magnetisation on the flexional elasticity of steel and iron rods. The magnetisation is a longitudinal one, and produced by surrounding the rod with a coil carrying a current. The conclusions arrived at from the experiments are: (1) Magnetisation of an iron or steel rod increases its torsional elasticity. (2) The effect is greater in iron than in steel rods of the same dimensions. (3) The increase in elasticity varies with the length of the rod.

Comparing these results with those of the experiments in flexional elasticity there is a distinct agreement. In the first place the modulus of elasticity is increased in each case when the rod is magnetised: the increments are fairly proportional to the magnetising forces, and they are inversely proportional to the magnitudes of the original stresses. E. C. R.

1312. *Change in Length of Soft Iron in Alternating Magnetic Fields.* **L. W. Austin.** (Phys. Rev. 10. pp. 180–186, March, 1900.)—Near the end of the core under examination hangs a glass fibre about 0·06 mm. in diameter. This fibre passes between two glass plates and carries a mirror. When the iron core elongates one glass plate is moved and this rolls the fibre, giving a

deflection of the beam of light reflected from the mirror. The main observations were on a bundle of ten wires of soft Swedish iron each 27·5 cm. long and 1·4 mm. in diameter. The magnetising solenoid was 24 cm. long with 12 turns per cm. The dilatometer gave a magnification of about 127,000 times with the scale 860 cm. distant.

The chief results are as follows : (1) The general course of the change in length of soft iron in an alternating magnetic field is the same as in the direct field. (2) For all values of H from 25 to 875 the change in length of the soft iron specimen is less with an alternating than with a direct field. (3) The maximum elongation gradually becomes less as the frequency of the alternations is increased. E. H. B.

1313. *Diamagnetism of the Eye.* **J. Mooser.** (Phys. Zeitschr. 1. p. 75, 1899.)—The author finds that the lens of the eye is diamagnetic, and suggests that a magnetic treatment might flatten the lens and cure shortsightedness. G. H. B.

1314. *Magnetism and Molecular Volume.* **S. Meyer.** (Ann. d. Physik, 1. 4. pp. 668–672, April, 1900.)—Previous work has shown that in some diamagnetic compounds the molecular magnetism shows a greater diamagnetic value than would correspond to the sum of the atomic magnetisms. This happens in every case where the combination is accompanied by any considerable expansion, as in the iodides of silver, mercury, and lead. This suggests that the converse might occur in the case of a contraction of volume, and for deciding this question the salts of copper, with their small susceptibilities, are specially fitted. Measurements made on a number of copper salts show that there is no fundamental difference between cupric and cuprous salts as supposed by Wiedemann, since both the sulphides are diamagnetic. But there is a very decided and regular influence of volume changes. Expansion emphasises the diamagnetic character of a substance, and contraction emphasises its paramagnetic character. The magnetic properties of the elements can therefore only be obtained from the elements themselves, or from compounds whose formation entails no change of volume. E. E. F.

1315. *Magnetic Susceptibilities of Vanadium and Samarium.* **S. Meyer.** (Ann. d. Physik, 1. 4. pp. 664–667, April, 1900.)—The magnetic susceptibility of vanadium chloride was measured by the author's method in which the dissolved substance is contained in a cylindrical tube suspended by one arm of a balance in a magnetic field. The value obtained for the magnetic susceptibility of VCl_3 is $1{\cdot}25 \times 10^{-6}$. This gives a value for the susceptibility of the element which ranges it in the series of metals of the iron group as follows :—

$$V : Ni : Cr : Fe' : Co : Fe : Mn = \tfrac{1}{4} : 2 : 2\tfrac{1}{4} : 3 : 4 : 5 : 6.$$

This relation is, however, only provisional, and may be invalidated by future measurements.

Samarium sulphate gives a susceptibility of $11{\cdot}2 \times 10^{-6}$ for Sa, a value which is in good agreement with the values derived from the oxide and nitrate. For gadolinium a higher value is obtained than that previously found. This may be due to the salt containing impurities of a substance of high magnetic susceptibility. This is made probable by Exner and Haschek's discovery that both samarium and gadolinium contain an unknown substance which is revealed by a large number of spectrum lines. The author has shown that there is an intimate connection between the prevalence of spectrum lines and strong magnetism. E. E. F.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1316. *Combinations of Carbon Disulphide with Gases under the Silent Discharge.* **Berthelot.** (Annal. Chim. Phys. 19. pp. 145–150, Feb., 1900.)—Under similar conditions to those referred to in Abstract No. 1109 (1900), CS_2 vapour unites readily with half its volume of hydrogen, yielding a yellow resinous product smelling like mercaptan, insoluble in ether and sparingly in CS_2, decomposed by cold potash to form a little sulphide. The formula $C_2H_2S_4$ corresponds to a persulphuretted oxalic acid, or a derivative of glyoxal, $C_2H_2O_2$. With weak tensions the CS_2 polymerises more rapidly than it combines with H. Nitrogen combines in the proportions of $4CS_2 : N_2$, argon in those of $84\ CS_2 : A_2$; the latter compound is decomposed, like ozone, by strong sparks. In the case of CO, 100 vols. of CS_2 with 60 of CO left after ten hours' action only 8·5 vols. of CO without any CO_2, and a yellow solid partly soluble in water; the filtrate contained an "oxysulphuretted" acid converted into sulphuric by boiling HNO_3. [*Cf.* Abstract No. 1050 (1899)].
S. R.

1317. *Action of Light and Silent Discharge.* **Berthelot.** (Annal. Chim. Phys. 19. pp. 150–154, Feb., 1900.)—When exposed in sealed tubes for three months at ordinary temperatures either to diffused light or to bright sunshine, pure benzene, either alone or in contact with hydrogen, argon, or mercury, undergoes no change. With oxygen there is a slow absorption and production of resinous polymerides.

Carbon disulphide is acted on by direct sunshine and by mercury, but not by diffused light, and does not combine under these conditions with H or argon.

On the other hand, when the apparatus described in Abstract 1109 (1900), was charged with a mixture of argon and CS_2 vapour, and its poles connected with a battery of Leclanché cells, without a coil, so that a difference of potential of 200 volts was maintained to the end, after three months in diffused light, although no argon had been absorbed, yet 60 per cent. of the CS_2 had been changed into yellow condensed products. S. R.

1318. *Distillation of Metals.* **G. W. A. Kahlbaum.** (Phys. Zeitschr. 1. pp. 62–64, and 67–69, 1899. Paper read before the Naturforscherversammlung zu München.)—This paper describes experiments on the distillation of elements in high vacua (up to 0·00005 mm. pressure for the distillation of gold, silver, copper, and iron at 1100° C.). Se, Te, K, Na, Li, Tl, Bi, Sb, Cd, Mg, Al, Ag, Cu, Au, Ni, Fe, Cr, Zn, and Zr, have all been distilled in this way, and 1 grm. of copper has been separated from 8 grms. of nickel by the fractional distillation of a German cupro-nickel 10-pfennig piece. W. G. M.

1319. *Emission and Absorption of Water-vapour by Colloidal Matter.* **P. Duhem.** (Journ. Phys. Chem. 4. pp. 65–122, Feb., 1900.)—In van Bemmelen's experiments on the hydration and desiccation of colloidal jellies, like gelatinous silica or colloidal ferric oxide, when placed in an atmosphere of water-vapour the effects are very complex. Considering them to be due to the absorption of water-vapour by a body being affected by hysteresis, the author investigates

the phenomena of incipient dehydration by the simple method already devised [see Abstract No. 1228 (1898)] for hysteretic changes in general, obtaining an expression for the speed of hydration, account being taken of the variations of pressure that are both perceptible and imperceptible. Comparison of the consequences of this expression with van Bemmelen's results is satisfactory in every way. Special stress is laid on the need of considering what the author calls *the region of secular variations* for any particular time in question. When dehydration has reached an advanced stage new phenomena occur, the water-content being now not sufficient to characterise the state of the hydrated body; the author therefore investigates the conditions of equilibrium on the assumption that they involve another variable, as well as the hydration, which is subject to hysteresis, and finds that all the observations, which are otherwise explained by van Bemmelen, can be readily interpreted and classified by this theory. R. E. B.

1320. *Motion of Crystals in Solvents.* **K. Schaum.** (Phys. Zeitschr. 1. pp. 5–6, 1899. S.ber der Gesellschaft zur Beförderung der gesamten Naturwissenschaften zu Marburg, June 21, 1899.)—This paper deals with the motion of substances while dissolving, analogous to the well-known motion of camphor in water. The substances dealt with are mostly salts readily soluble in water and dilute acids, KCN, KNO_3, $AgNO_3$, KCl, $CaCl_2$, $KMnO_4$, $K_2Cr_2O_7$, Sugar, Hydroquinone, and Urea. The crystal is dropped on to the top of a layer of mercury covered by the solvent and the motion then observed. The motion is always greater in dilute acid than in water. The nature of the motion is very characteristic. The crystal generally moves at first in a zigzag path, which changes to a circular one, and finally it rotates very rapidly on its axis. There is no doubt that the phenomena are connected with the rate of solution. A crystal of $KMnO_4$ covered with paraffin at all except one point moved always in the opposite direction to the current of solution, and when two points diametrically opposite are bared the crystal rotates rapidly on its axis. The experiments show that the rate of motion depends on the rate of solution and on the surface tension of the mercury, anything which alters the latter also altering the rate of motion. J. B. H.

1321. *Formation and Transformation of Mixed Crystals of Mercuric Bromide and Iodide.* **W. Reinders.** (Zeitschr. Phys. Chem. 32. pp. 494–536, March 20, 1900.)—The theoretical conclusions of Roozeboom [see 1900, Abstracts Nos. 678 and 679] are applied to the case of mercuric bromide and iodide on similar lines to those adopted by van Eyk [see 1900, Abstract No. 680] in the study of thallium and potassium nitrates. At the melting-temperature mercuric iodide and bromide form a complete series of mixed crystals; the iodide melts at 255·4° and the bromide at 236·5°, whilst a minimum melting-point is reached in the case of a mixture containing 59 mols. per cent. of the bromide which melts at 216·1°; the mixture is thus of the third type (Roozeboom, *loc. cit*). The composition of the crystals which separate from a melt of known composition was determined for a number of cases, but in no case was there a difference of 2 per cent. in the composition of the solid and liquid phases.

Mercuric iodide exists in two modifications, a yellow rhombic form which is stable above 127°, and a red tetragonal modification which is stable below that temperature. The bromide is only known in one form, isomorphous with the yellow iodide; its transition-point evidently lies far below the atmospheric temperature. At the temperature of the melting-point the iodide and bromide

form a complete series of isomorphous crystals. The transition-point of mercuric iodide is lowered by the addition of the bromide, and at the same time it is broadened into a transition interval. Thus above 127° only yellow crystals can exist, but at 50° mixtures containing less than 4·3 mols. per cent. of $HgBr_2$ are red, and mixtures containing more than 15·5 mols. per cent. are yellow, whilst mixtures containing between 4·3 and 15·5 mols. per cent. consist of an aggregate of red and yellow crystals, the colour being an intermediate tint between the yellow and red; the corresponding limits at 25° are 6·2 and 21·8 mols. per cent. of $HgBr_2$, and at 0° 8·6 and 33·0 mols. per cent.

The change from one modification to the other is in this case very gradual, and greatly increases the experimental difficulties, but the striking difference in colour between the two modifications makes the optical method of special value. T. M. L.

1322. *Formation and Transformation of Mixed Crystals of Sodium Nitrate with Potassium and with Silver Nitrates.* **D. J. Hissink.** (Zeitschr. Phys. Chem. 32. pp. 537–563, March 20, 1900. *Cf.* Roozeboom, Abstracts Nos. 678 and 679 (1900), van Eyk, Abstract No. 680 (1900), and the preceding Abstract.) —The melting-point curve for mixtures of sodium nitrate (m.p. 308°) and potassium nitrate (337°) has been plotted by Carveth (Journ. Phys. Chem., 2·209) and found to show a sharp break at the minimum melting-point (218°) of a mixture containing 49·3 mols. per cent. of $NaNO_3$; the mixture is thus of the fifth type (Roozeboom, *loc. cit.*). The composition of the crystals which separate from a melt of known composition has now been determined, and it is shown that at 218° there is a gap in the series of mixed crystals from 24 to 85 mols. per cent. KNO_3, mixtures of intermediate composition solidifying to an aggregate of both forms. The transition-point of potassium nitrate is lowered by the addition of sodium nitrate, and is broadened into a transition interval.

The melting-point curve of mixtures of sodium nitrate (308°) and silver nitrate (208·6°) is of the fourth type, rising continuously as the proportion of $NaNO_3$ increases, but showing a sharp break at 217·5°, the melting-point of a mixture containing 19·5 mols. per cent. of $NaNO_3$. In this case the crystals are always richer in $NaNO_3$ than the liquid from which they separate, but there is a gap in the series of mixed crystals from 26 to 38 mols. per cent. $NaNO_3$, although the two series of crystals on either side of the gap are isomorphous; this gap widens as the temperature falls and extends from 4·5 to 50 mols. per cent. at 138°, and from 1·6 to 64·4 mols. per cent. at 15°.

Sodium nitrate is only known in the hexagonal-rhombohedral system, but silver nitrate passes into the rhombic system below 159·8°; the transition-point falls to 138° on adding 4·5 mols. per cent. of $NaNO_3$, but cannot be lowered any further as a mixture containing a larger proportion of $NaNO_3$ solidifies to a conglomerate of the two series of rhombohedral crystals. Rhombic mixed crystals rich in $NaNO_3$ might be expected to appear at lower temperatures, but this could not be realised experimentally. T. M. L.

1323. *Freezing-Point of Water containing Hydrochloric Acid and Phenol.* **J. A. Emery** and **F. K. Cameron.** (Journ. Phys. Chem. 4. pp. 130–134, Feb., 1900.)—Freezing-points are given for solutions of phenol in water and in solutions of hydrochloric acid of various strengths up to N/2. The results show that the freezing-point of a saturated aqueous solution of phenol is −1·179°. The freezing-point curve for solutions of hydrochloric acid saturated

with phenol is a straight line parallel to the hydrochloric-acid curve; the depression of the freezing-point of water by hydrogen chloride and phenol is hence an additive effect. T. H. P.

1324. *Melting-Point of Ethyl Formylphenylacetate.* **C. G. L. Wolf.** (Journ. Phys. Chem. 4. pp. 123–129, Feb., 1900.)—When heated above its melting-point, ethyl formylphenylacetate suffers partial change into a tautomeric liquid modification, the time taken to re-solidify depending on the extent of the change. As determined in the ordinary way, the melting-point is variable, but if carried out in sealed capillary tubes, heated in a bath carefully stirred, the lowest temperature at which fusion occurs is 50°, which is hence the stable triple point. If after partial tautomeric change is produced by heating, the mass be rapidly cooled to − 80° and then allowed to stand in the air, solidification is greatly accelerated, crystals appearing after twenty-four hours; this is due to the fact that tautomeric change is more rapid the greater the difference between the actual point of unstable equilibrium and that of true equilibrium. T. H. P.

1325. *Ionisation of Gases.* **W. Kaufmann.** (Phys. Zeitschr. 1. pp. 22–25, 1899. Paper read before the Göttinger Philosophischen Fakultät, Aug. 12, 1899.)—The author discusses the differences between the migration of ions in gases and liquids respectively, and summarises the work done for determining ionic velocities in gases. The essential difference between gases and liquids is that in the former any E.M.F., however small, generates a current, while in liquids a certain minimum E.M.F. is required. On the other hand, there is in gases a certain superior limit of current strength which is never exceeded, however high the E.M.F. employed. That such a saturation current has never been observed in a liquid is due to the very high rate of reaction in electrolytes. Yet it is possible that liquids may be found to exist which do not strictly obey Ohm's law. The values obtained by Rutherford for the sums of velocities of ions in various gases show that approximately the mobility of the ions is inversely proportional to the square root of the molecular weight. The only exception to this rule so far observed is that of sulphurous anhydride, where the mobility has half the theoretical value.

E. E. F.

1326. *Taste and Degree of Dissociation of Acid Salts.* **L. Kahlenberg.** (Journ. Phys. Chem. 4. pp. 33–37, Jan., 1900.)—It has been shown by Richards and by the author that the strong mineral acids cannot be detected by the sense of taste in solutions containing less than 1 gram. mol. in about 1,000 litres. It is now found that solutions of the acid sodium salts of various dibasic organic acids possess an acid taste in solutions containing a considerably smaller number of hydrogen ions than is present in the acid solutions referred to. The acid taste of these salts is hence due, not to the hydrogen ions in the solution, but to the monovalent ions of the formula HAc.

T. H. P.

1327. *Potential Differences with Manganese Dioxide Electrodes.* **O. F. Tower.** (Zeitschr. Phys. Chem. 32. pp. 566–577, March 20, 1900.)—This paper is a further contribution to the method of measuring the concentration of hydrogen ions by means of the P.D. at a manganese dioxide electrode, a method which is specially suited to the investigation of acid salts (*cf.* Zeitschr. Phys. Chem. 18–35, 1895, and W. A. Smith, Zeitschr. Phys. Chem. 21–93, 1896). T. M. L.

1328. *Minimum E.M.F. for Electrolysis.* **A. Gockel.** (Zeitschr. Phys. Chem. 32. pp. 607-624, March 20, 1900.)—In this paper experiments are described, the results of which show that there is no minimum E.M.F. necessary to start electrolysis, but that electrolysis takes place under the smallest E.M.F.'s. Curves are plotted having E.M.F.'s for abscissæ, and current strengths for ordinates. These curves from the start, *i.e.*, from the point at which the current becomes measureable, have an upward slope showing a gradual increase of current with increase of E.M.F. At certain points the inclination increases rapidly and then resumes more or less the straight line form, but the different portions which are approximately straight do not meet at sharp angles but are connected by transition curves. These changes in the slope of the curve take place at the points at which the physical conditions are altered, *e.g.*, the point at which bubbles begin to be evolved.

The current strength for these curves was always observed three minutes after the application of the E.M.F. The electrolytes were solutions of H_2SO_4, KOH, and $ZnBr_2$, and platinum electrodes both in the form of wires and plates were used. J. B. H.

1329. *Electrolytic Conductivity of Sodium Salts of Nitroparaffins.* **O. Šulc.** (Zeitschr. Phys. Chem. 32. pp. 625–629, March 20, 1900.)—The conductivity of solutions of the sodium salts of nitromethane, nitroethane, nitropropane, and nitroisopropane are here determined. The molecular concentrations of the solutions of each salt were 32, 64, 128, 256, 512, and 1,024, and a table is given for each. The following table gives the conductivities for the greatest and least concentration, and their differences, $\Delta = \mu_{1024} - \mu_{32}$.

Sodium salt of	μ_{1024}	μ_{32}	Δ
Nitromethane	108·6	84·4	24·2
Nitroethane	81·9	69	12·9
Nitropropane	80·8	67·8	13·0
Nitroisopropane	93·1 ?	65·0 ?	28·1 ?

J. B. H.

1330. *Production of Ozone.* **H. Bordier** and **Moreau.** (Archives d'Él. Médicale, 8. pp. 57–65, Feb. 1900.)—The authors give the results of experiments made with high-frequency currents and the "Résonateur" or Solenoid of Oudin. The latter is described, but the description requires the accompanying figure. The ozone produced by the non-sparking discharge was estimated quantitatively by the iodine and arsenious acid method. Special tests were made for nitrous products, but always with negative results. It was found that when copper wire was used for the discharge terminal of the apparatus, it became coated with crystals of oxide before the production of ozone attained its maximum, and the authors therefore recommend that copper should be replaced by some less oxidisable metal, or should be plated with gold before use in the Oudin apparatus.

A Rhumkorff coil taking a primary current of 9½ amps., at 58–60 volts, with a Wehnelt interrupter was used in the experiments. Under normal conditions 100 litres of air were aspirated and 65 mgs. ozone were produced per half hour. By increasing the volume of air aspirated it was found possible to greatly increase the yield of ozone. As regards the electrical efficiency of the apparatus, the authors found that while 8 amperes at 48 volts yielded 18 mgs. ozone, 9½ amperes at 60 volts yielded 62 mgs. ozone, the volume of air

ng 92 litres. They also found that a higher yield was obtained
of the sparking length at the terminals of the induction coil.
eriments proved that the non-sparking discharge was the best
r a maximum yield of ozone. The authors regard an output of
of ozone per hour as the highest obtainable with the apparatus
They intend to extend their investigations, and to study the
alue of ozone when inhaled. J. B. C. K.

. *Electrolytic Hypochlorites.* **V. Engelhardt.** (Elektrochem. Zeitschr.
253–258, March, 1900, from "Oesterr. Chemiker Zeitung.")—The
after discussing the numerous advantages attending the use of
lytically prepared hypochlorites for bleaching purposes, alludes to the
the price of calcium hypochlorites, and states that when large quantities
to be dealt with electrolytic bleaching will only pay if salt and electric
er can be obtained at very cheap rates. The author confirms the
ervation first made by Cross and Bevan, that hypochlorite electrolytically
pared, from magnesium or sodium chloride solutions, has a higher
eaching efficiency than the hypochlorite prepared from ordinary bleaching
owder, and for solutions of sodium hypochlorite he places the ratio of
fficiency at 5 : 4. His experiments have also proved that dilute solutions
of sodium hypochlorite prepared by electrolysis, are more stable than those
of calcium hypochlorite, in the light.

The author next discusses the conditions requisite for the production of hypochlorites in the electrolytic cell, and then gives some historical notes relating to the development of electrolytic bleaching processes. The cells of Hermite, Stepanoff, Andreoli, Kellner, Vogelsang, Blackman, Weiss, Schuckert and Co., and of Haas and Oettel are briefly described, and information is given concerning the industrial use of these. The author closes by stating that the problem presented by the electrolytic production of bleaching solutions is now solved, and that the future of the best cells and processes depends only upon local conditions, the growth of the electrolytic alkali and bleach industry, and the price of bleaching powder. J. B. C. K.

1332. *Electrolytic Reduction of Nitrobenzene.* **F. Haber** and **C. Schmidt.** (Zeitschr. Phys. Chem. 32. pp. 271–287, Feb. 20, 1900.)—According to the authors' views of the reactions accompanying the electrolytic reduction of nitrobenzene in alcoholic ammonia solution, phenyl-β-hydroxylamine is formed as an intermediate product; its existence in the reduced solution has, however, only been observed in acid solutions, owing to the fact that in presence of caustic alkali, the phenyl-hydroxylamine suffers decomposition with formation of azoxybenzene and aniline. This decomposition should be avoided by using a solution in which the concentration of the hydroxyl ions is small. The authors find that phenyl-β-hydroxylamine is obtained when the kathode compartment contains an alcoholic ammonia solution of ammonium chloride
the reduction being carried out in the cell devised by Haber [see 1899
Abstract No. 333]; a considerably less current may be employed than
necessary for the reduction in acid solutions. It is also shown that t
tion of azobenzene during the reduction of nitrobenzene is not
tion of previously formed azoxybenzene, but that it owes
nitrobenzene on hydrazobenzene by which
results confirm Haber's views of
itrobenzene in alkaline solu
T

1333. *Electrolytic Reduction of Non-Electrolytes.* **F. Haber.** (Zeitschr. Phys. Chem. 32. pp. 193–270, Feb. 20, 1900.)—The author deduces the formula $E = 0{\cdot}0436\ (\log I - \log C_{NO_2}) - \text{const.}$, for the P.D. between the kathode and kathode-solution in the electrolysis of an aqueous-alcoholic solution of caustic soda containing nitrobenzene as a depolariser, where I represents the current at 20° C., and C_{NO_2} the concentration of the nitrobenzene in gramme molecules per c.c. It was found that the P.D. was only influenced very slightly by the temperature, and a current of cold water was therefore used in place of a more elaborate thermostat. The kathode consisted of a platinum plate, of which only one side was in contact with the solution. The P.D. was measured by a new method, using a capillary electrometer, one terminal of which was connected with the kathode, whilst the other was connected through a vessel containing decinormal solution of KCl to a tube of decinormal KOH, the minute capillary end of the latter being placed in the kathode-solution quite close to the kathode plate.

Three series of experiments were made to verify the laws :—

$$(1)\quad E = 0{\cdot}0436 \log I - \text{const.} \quad (C_{NO_2} = \text{const.}),$$

$$(2)\quad E = 0{\cdot}0436 \log \frac{10}{C_{NO_2}} - \text{const.} \quad (I = \text{const.}),$$

$$(3)\quad \frac{I}{C_{NO_2}} = \text{const.} \quad (E = \text{const.}),$$

With the exception of two experiments in which some unknown cause of disturbance was present, all the measurements showed a linear relationship between concentration and current, as required by law (3), when the current was adjusted to a constant P.D. for varying concentrations of nitrobenzene; the values were most concordant when the value of the P.D. was high. For variations of current from 2·4 to 112 amperes per square metre, the P.D. varies according to law (1) when the constant concentration of the nitrobenzene lies between ⅕ and ⅓ mols. per litre. In six series of experiments with constant current it was found that the experimental factor was always greater than 0·0436, the deviations being greatest when the constant value of the current density was relatively great, since the nitrobenzene then becomes impoverished in the neighbourhood of the kathode. T. M. L.

REFERENCES.

1334. *Theory of Voltaic Cell.* **A. Righi.** (Elect. Rev. 46. pp. 245–247, Feb. 9, 1900.)—This is an appendix to the author's lecture on Volta, delivered at Como, September 18, 1899 (see 1900, Abstract No. 217), and gives a general account of the chemical, contact, and osmotic theories. W. R. C.

1335. *Thermodynamic Relations of Hot Water and Soft Glass.* **C. Barus.** (Amer. Journ. Sci. 9. pp. 161–175, March, 1900. Lecture delivered before the Physical Society of the University of Göttingen.)—This paper appears to be chiefly a summary of the author's work on the above subject. Reference may be therefore made to previous Abstracts, viz., 1899, No. 1045, and 1900, No. 220. F. G. D.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

1336. *Cost of Steam Raising.* **J. Holliday.** (Inst. Elect. Engin., Journ. 29, pp. 38–61. Discussion, pp. 77–117, Jan., 1900.)—This paper deals with the work of a boiler, regarding steam in the pipes as the manufactured article and fuel as the chief raw material. The evaporation of 1,000 gallons of water is taken as the unit work in the boiler. Starting from B. Donkin's figures that the cost of dust coke per unit evaporative work is only about one-third of that of large Welsh coal, the author discusses the disadvantages of the low-priced, poorer fuels—difficulty of burning, more boilers required, more labour needed—which weigh against this economy. Measurements extending over a long period (figures are given for the year 1895) were made on a steam-raising plant consisting of nine approximately equal Lancashire boilers working at 60 lbs. pressure; the demand for steam being fairly constant during the twenty-four hours. All the boilers were hand fired. In three boilers, "breeze," costing 3s. 6d. per ton, was burned, forced draught being used; the mean cost of *fuel alone* per unit was 2s. 8¼d.; each boiler evaporating 2,700 lbs. of water per hour. The other boilers burned a good South Wales coal without forced draught; the mean cost of *fuel alone* per unit being 6s. 9¾d.; evaporation per boiler 3,800 lbs. per hour. Expenses of working, maintenance, insurance, interest, and depreciation come more heavily on the boilers using the poorer fuel than on the others; including these the costs per unit are 7s. 3½d. and 9s. 2d. respectively. Very detailed tables and diagrams are given. H. R. C.

1337. *Cheap Fuels and the Cost of Electrical Energy.* **R. E. Crompton.** (Inst. Elect. Engin., Journ. 29. pp. 62–77. Discussion, pp. 89–117, Jan., 1900.)—After pointing out that, in many instances, as soon as appliances are arranged to use a cheap fuel systematically, so soon is either the price raised or the supply exhausted, the author states that there are large supplies of slack coals available at the collieries in the Midlands and in the North which could in future be delivered within a radius of fifty miles at a cost of about 5s. 4d. per ton, including carriage; beyond that distance it is probably only rarely economical to pay carriage on very cheap fuel. Three classes of cheap fuels are discussed; (1) the anthracitic coals and refuse coke dealt with in the previous paper; (2) the free burning small coals of the Midlands; (3) the small caking coals of the North. The difficulty in the direct burning of the latter two classes is in breaking up the clinker so as to allow a proper supply of air at points in the furnace. Descriptions and diagrams are given of the Babcock and Wilcox revolving grate. In order to obtain increased area of grate and to promote smokeless combustion it is recommended that the revolving grate should project in front from under the boiler into an arched fire-brick combustion chamber. At Chelmsford the ratio of cost of fuel per B.T.U. to total cost is 64 per cent. when using coal at 17s. 5d. per ton; if coal at 5s. 4d. were available it is calculated that the ratio would be only 35 per cent. A table is given of a complete test of a Babcock boiler with revolving grate. In the discussion **J. Perry** pointed out that for stations

with a high load factor it is better to use a cheap fuel, while for a low load factor a more expensive coal would be better; for a load factor of about 15 per cent. they would probably be equally economical. **W. Geipel** referred to the advantages of a rib beneath the furnaces of a Lancashire boiler in promoting circulation and hence getting up steam more quickly. **F. J. Appleby** considered the powdered fuel method to be the best way of burning the small bituminous coals of the North. H. R. C.

1338. *Efficiency of Steam Boilers and Surface Condensers.* **T. E. Stanton.** (Mech. Eng. 5. pp. 445–448, March 31, 1900. Paper read before the Owens College Engineering Society.)—This communication refers to experiments made by the author which confirm Osborne Reynolds's theory that the rate of transmission of heat between a metal surface and a fluid in contact with it, for a given difference of temperature between the surface and the fluid, is proportional to the quantity of the fluid carried up to the surface in unit of time. The author's experiments on water show that the rise in temperature of water flowing through a tube, the surface of which is kept at a constant temperature, is practically the same at all velocities above the critical velocity at which eddying motion is established in the tube. The paper is illustrated by diagrams showing the temperature in a condenser, having a tube surface of 176 square feet when the supply of cooling water is 15·5 pounds and 25 pounds respectively per pound of steam. In another diagram the relation between length of tubes and condenser pressure is shown for the three cases of tubes $\frac{3}{8}$ inch, $\frac{5}{8}$ inch, and $\frac{7}{8}$ inch in diameter. The curves clearly show that the smaller the diameter of the tube the less the effective length need be to produce a given pressure. As an example with a given supply of steam and cooling water, the effective lengths of tube for a pressure of 1·68 pounds per square inch would be proportional to 26·8, 18·2, and 10·0 for tubes of $\frac{7}{8}$, $\frac{5}{8}$, $\frac{3}{8}$ diameter respectively.

A diagram is given, indicating the arrangement of tubes suggested by the results of these experiments for a condenser of high efficiency. E. C. S.

1339. *Rules for Conducting Steam Boiler Trials.* (Engineering, 69. pp. 271–272, Feb. 23, 1900. Report presented at the Dec. (N.Y.) Meeting of the American Society of Mechanical Engineers.)—The following is a short epitome of the rules laid down for conducting boiler trials:—

(1) Determine accurately object for which trial is instituted and scope of same. (2) Examine boiler carefully both inside and outside, recording all the principal dimensions, giving sketches when possible, state heating surface (both "water heating" and "steam heating") and grate surface.

(3) Note general conditions of boiler and setting and their relation to the object of the trial. Ensure cleanliness and absence of leaks either of air or steam. (4) Determine character of coal. (5) Calibrate all measuring tanks, scales, gauges, thermometers, &c.

(6) See that the boiler and setting are thoroughly heated before test commences.

(7) Boiler and connections must be free from leaks, and all connections other than those actually in use should be blank-flanged and should remain as far as possible in view during trial.

(8) Duration of trial should be as long as can be conveniently arranged for; if possible, not less than twenty-four hours if test is conducted under ordinary working conditions with change of stokers, &c.

(9) Conditions at the start and finish of the trial should be identical as far as possible.

(10) "Standard" method of starting trial consists in raising steam to working pressure, removing fire and ashes, making new fire of weighed quantity of wood and coal, noting the time and the water level. At the end of the test remove whole fire, clean grates and ashpit, noting time and water level, which should be as nearly as possible what it was at commencement of trial.

(11) "Alternate" method of starting trial. Burn fires low and clean. Note fuel left on grate as accurately as possible, also steam pressure and water gauge. Take time of starting and weigh fresh coal as it goes on. Towards end of trial bring fires as nearly as possible to the same condition as at starting, and make same observations as to quantity of coal on grate, water level and steam pressure, and make the necessary allowances.

(12) Endeavour to obtain uniformity, as far as possible, of conditions throughout the duration of the trial and also for any trials which have to be compared with one another. (13) Take note of every event occurring during the trial and time of its occurrence. Stoking and feeding must be by equal quantities at equal intervals. (14) Percentage of moisture in the steam should be determined by means of a calorimeter, and if necessary a separator should also be added. Superheating should be determined by a thermometer placed in a mercury well in the steam-pipe.

(15) Samples of coal should be collected throughout the trial and then gradually reduced until a fair average sample of about 5 lbs. is procured, which should then be placed in an air-tight glass for subsequent analysis. (16) Representative samples of the ashes should also be procured for the same object. (17) The calorific value of the coal should also be determined by a competent chemist. (18) The fuel gases should also be sampled at stated intervals and the analysis made by an expert chemist, or the Orsat and Hempel apparatus may be used for an approximate determination. (19) Observations of the quantity of smoke should be made. (20) Efficiency may be calculated in either of the following methods :—

$$(a)\ \text{Of boiler} = \frac{\text{Heat absorbed per lb. of combustible}}{\text{Calorific value of 1 lb. of combustible}}$$

$$(b)\ \text{Of boiler and grate} = \frac{\text{Heat absorbed per lb. of coal}}{\text{Calorific value of 1 lb. of coal}}$$

(21) Heat balance should, where possible, be added to all results of trials.

L. S. R.

1340. *Mean Pressure Indicator.* **W. Ripper.** (Inst. Mech. Engin., Proc. 4. pp. 569–584. Discussion, pp. 584–612, 1899. Mech. Eng. 5. pp. 122–124, Jan. 27, 1900.)—A description of the author's indicator for measuring the mean effective pressure on the pistons of high-speed engines. The readings are taken on two gauges, one of which is always in connection with the driving or high pressure side of the piston, and the other is always in connection with the back pressure side. The difference in the readings of the gauges is the mean effective pressure. Oscillations of the gauge fingers are controlled by throttling the steam by means of two cocks on the pipe leading to each gauge. The author describes the different forms of the instrument, and then considers the mean pressure given by his indicator in comparison with those given by the ordinary type of indicator, as the mean pressures given by an ordinary indicator are on a distance base, while with

[redacted]

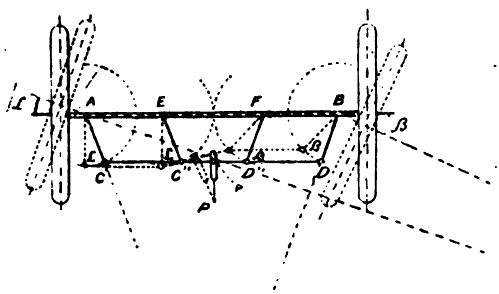
this instrument they are on a time base, and shows how to obtain a factor for reducing one to the other. The author next deals with the care of pressure gauges, and describes the experiments carried out to ensure the gauge syphon remaining full of water and free from agitation, which he effects by means of two cocks for throttling the steam.

In the discussion **H. Lea** described a continuous indicator brought out by himself. **S. H. Terry** described a dial steam power meter designed to register (1) the mean effective pressures on piston, (2) the speed of the piston, and (3) the I.H.P. **E. Savage** wrote of Janet's experiments at Creusot on similar lines to the author's.

Numerous illustrations accompany the paper. L. S. R.

AUTOMOBILISM.

1341. *Steering Gear.* (Locomotion Automobile, 7. pp. 279–280, May 3, 1900.) —A description of Griffisch's arrangement of levers whereby more correct positions of the steering wheels of motor vehicles are obtained when turning.



Five diagrams are given explaining the method employed. The figure, reproduced, shows the arrangement very clearly; P is the centre about which the mechanism is operated by the driver; the lines A C and B D intersect at the centre of the rear axle of the vehicle. A. G. N.

1342. *Uses of Acetylene.* **Janet.** (Ecl. Électr. 22. pp. 197–200, Feb. 3, 1900. Paper read before the Société d'Encouragement pour l'Industrie Nationale, Jan. 26, 1900.)—For lighting purposes acetylene gas is (1) produced from calcium carbide in a generator where used; and (2) the gas is stored under pressure or in solution in a suitable portable receiver. Compressed acetylene may be used to light carriages and for railway signals (instead of oil gas) at a cost of 0·8 centime per *carcel-heure.* Two small types of generators are described. W. R.

REFERENCES.

1343. *Combustion and Forced Draught.* **R. B. Hodgson.** (Mech. Eng. 4. pp. 963–970, Dec. 30, 1899, and 5. pp. 22–24, Jan. 6, 1900. Paper read before the Birmingham Association of Mechanical Engineers, Nov. 4, 1899.)—The author describes the combustion, constituents, and calorific values of coal of several qualities; the amount of air required for combustion, the different methods of forcing and inducing draught, and their relative advantages and disadvantages. J. T. R.

1344. *Balancing Marine Engines.* **J. Macfarlane Gray.** (Engineering, 69. p. 487, April 13, 1900.)—The author gives some geometrical constructions, and refers to papers by himself in the Transactions of the Institution of Naval Architects.

GENERAL ELECTRICAL ENGINEERING.

1345. *Characteristic Curves of Accumulators.* **M. Kohn.** (Elektrotechn. Zeitschr. 21. pp. 78–80, Jan. 25, 1900.)—The method of tracing the characteristic curve of a battery is described, the ordinates representing terminal voltage, and the abscissæ the current on charge and discharge. By plotting on the same diagram the characteristic curve of a dynamo, the proportion of an external load which will be taken by each when connected in parallel can be determined. The effects of internal resistance of the cells and of variations of dynamo speed are traced and the method detailed of designing the capacity and resistance of a buffer battery required to effect any desired damping of the variations due to external load, as on a tramway circuit. L. B.

1346. *Accumulator Charge Indicator.* (Electrician, 44. pp. 781–782, March 23, 1900. From a description by **Bellati** in the Centralblatt für Accumulatoren- ŭ. Elementenkunde, No. 3.)—The indicating medium is a column of some liquid, such as petroleum, which is of less sp. gr. than the electrolyte, and does not mix with it. The liquid is contained in a glass tube, which passes up vertically through the electrolyte, and then just above its surface bends over nearly at a right angle, forming a slight slope with the horizontal. The tube is open at both ends, and small changes of sp. gr. cause a considerable travel of the top of the column of liquid along its sloping portion which may be graduated in millimeters or direct in ampere-hours. The precautions to be observed to obtain correct readings with the instrument are given.

E. J. W.

1347. *Active Materials for Lead Accumulators.* (Electrician, 44. pp. 785–786, March 23, 1900. From an article by **A. Heinemann** in the Centralblatt für Accumulatoren- ŭ. Elementenkunde, No. 5.)—The use of organic substances for mixing with the lead oxides for pasting purposes is discussed. Materials which furnish products of a resinous nature upon oxidisation are preferred, and the author favours a strongly compressed active material of small porosity, agglomerated with oils of cypress, birch, or pine. E. J. W.

1348. *Accumulators.* **M. U. Schoop.** (Zeitschr. Elektrotechn., Wien, 18. pp. 101–106, Feb. 25, 1900.)—This is a paper dealing with a series of tests of positive and negative plates of accumulators for the purpose of ascertaining their relative capacities at different rates of discharge. The method employed was to take readings at intervals between the plates and a neutral electrode of mercury—a known method—during discharge. The results are summed up as follows: (1) Negative plates are much more sensitive to excessive rates of discharge than positive (peroxide) plates of the same absolute capacity. Put in another way, this means that a given battery, which will, if discharged at a slow rate, give so many ampere hours, will, of course, when discharged at a a high rate, give less; *but* that the difference is due to loss of capacity at the high rate on the part of the negatives—not on the part of the positives. (2) Compared with pasted negatives, Planté *negatives* lose their capacity in from 10–25 discharges. (3) In Planté *positives* the active material is used more effectively *than in pasted* positives, *but* the pasted positives "pick up" better on a rest.

(4) In Planté batteries where negative and positive capacity is about equal, the resistance is distributed in practically the same way as in Faure batteries. (5) Generally, and more especially when the batteries are exposed to extreme loads (buffer batteries and motor-car batteries), the capacity of the negatives should be greater than that of the positives. R. N. L.

1349. *Accumulators in the Paris Club Trials.* **A. Bainville.** (Électricien, 19. pp. 51–55, Jan. 27, 70–78, Feb. 3, 81–85, Feb. 10, 134–137, March 3, 149–158, March 10, 167–169, March 17, 1900.)—None of the cells stood the 158 complete charges and discharges. All were lead-lead cells, and some of the best are entirely new designs. The "Metaux" and "Pollak" are minutely detailed and illustrated. In pages 70–78 are described the "Tudor" and "Pescetto" cells; the grids of the latter are particularly intricate. In pages 81–85 the author describes the "Blot Fulmen," which has special provisions for free expansion of the positive paste by supports made of wavy strips unconfined laterally. The "Fulmen" has grids filled with cakes of paste. "Phoenix" plates consist of small pasted cylinders 2 mm. in diameter protected individually by a continuous pile of ebonite washers 1 mm. thick. The "Pope" positive plate consists of seven lead spirals pasted and protected by a spiral of ebonite which covers half its surface. The negative is a pasted grid. [See also Abstracts Nos. 952 and 953 (1900).] M. O'G.

1350. *150-Ton Electric Crane at Bremerhaven, Germany.* (Eng. News, 43. pp. 99–101, Feb. 8, 1900; from the "Zeitschrift des Vereines deutscher Ingenieure.)—The superstructure of the crane consists of a rigid supporting tower and a revolving mast supported at the foundation and at the top of the tower; the mast itself is a framework structure, and carries at the top a double-armed cantilever truss. The carriage with the hoisting gear runs on the cantilever, and the opposite end of the cantilever bears a counterweight so proportioned that the negative bending moment arising from it when the carriage is at its inner position equals the positive moment due to the maximum load at the extreme length of the arm. The total weight of the mast, counterweight, and load produces a vertical pressure which is transmitted from the mast through a hinge to a revolving platform resting on rollers. The total height of the crane is 118 feet from the top of the foundations, and the total reach is 72 feet, giving a useful reach of 44½ feet from the front of the masonry wharf to the middle of the hook.

The turning mechanism is actuated by a direct-current motor of 26 H.P. at 550 revs. per min.; a worm gear and spur gears transmit the motion to the mast in four reductions, the total reduction being 1:4,000. The cantilever therefore requires 7·2 minutes to make a complete revolution. The circumferential motion of the hook at its extreme position is therefore 81½ feet per min., and is accomplished under maximum load; with a smaller load a greater speed can be obtained.

The steel lifting cable is 2·36 inch diameter, and has a breaking strength of 150 tons over a pulley of 47½ inches diameter. The tackle-block has seven sheaves corresponding to eight plies of the cable. It did not seem practicable to wind the unusually long cable on a drum borne by the carriage; but two barrels or pulleys are provided which in their action correspond to a single pulley encircled an equal number of times. The number of turns is six, and the calculated tension in the cable as it leaves the last pulley is 16 lbs. The slack end of the cable runs upon supporting rollers to the middle of the mast, and to a pair of blocks, through which it makes twelve turns. The lower

block is weighted and runs between guides, the tension produced in the cable being 1,100 lbs.

Two series-wound motors, each delivering $17\frac{1}{2}$ H.P. at 450 revs. per min., operate the lifting tackle. They are connected by flexible couplings to a common spindle, from which the rotation is transmitted by two sets of spur gears to a third spindle lying between the two cable pulleys; on this latter spindle are fixed two pinions engaging with four spur wheels bolted to the pulleys. Two sets of electromagnetic and mechanical brakes are provided, all working automatically. The mechanical brakes act as a reserve in case of a failure of the magnetic brakes. They are fully described in the paper.

The movement of the carriage is effected by a motor which develops 26 H.P. at 550 revs. per min. The motion is transmitted by a worm gear to two pairs of spur gears. The motors operate at 110 volts, and are similar to street car motors. The weight of material used in the supporting tower and cantilever, turning machinery, cable and blocks, carriage and pulleys, is 412 tons. The weight of an American 150-ton crane referred to for comparison is 775 tons. A. S.

REFERENCES.

1351. *E. C. C. Electrical Lift Gear.* (Electrician, 44. pp. 289–290, Dec. 22, 1899.)

1352. *Meters.* **H. Armagnat.** (Écl. Électr. 21. pp. 161–172, Nov. 4; 295–301, Nov. 25; 412–419, Dec. 16, 1899.)—Illustrated description of meters of Sherman-White, Peloux, Boult, Routin-Brown, Mohrle, Marks, Locke, Thomson-Holden, and O'Keenan (pp. 161–172).—Meters of Bastian, Edison, Thomson, Allo, Soames, Crawley, and Raphael (pp. 295–301).—Recent improvements in meters including those of Long-Schattner, Batault, Laarman-Brockelt, Chamberlain and Hookham, Thomson, Davis, Staunton, Jones, and Evershed and Vignoles (pp. 412–419). (See also 1899, Abstracts Nos. 168, 1421.)

1353. *O'Keenan Electricity Meter.* **C. E. O'Keenan.** (Soc. Int. Élect., Bull. 16. pp. 391–409, 1899.)—Descriptive paper, including results. (See 1900, Abstract No. 580.)

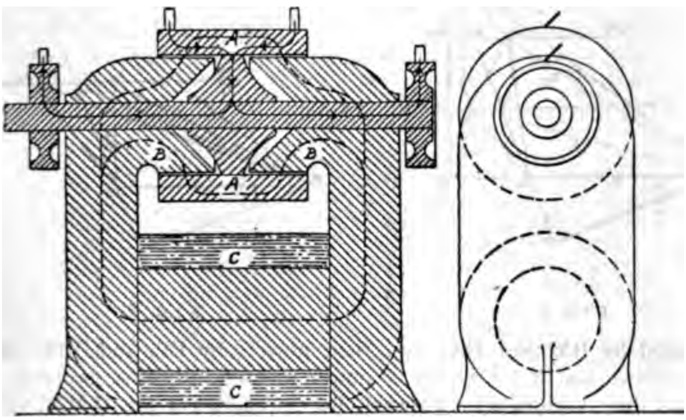
1354. *Electrical Engineering.* **S. P. Thompson.** (Inst. Elect. Engin., Journ. 29. pp. 14–35, Jan., 1900.)—This is an inaugural address in which the author gives an account of the present position and tendencies of electrical engineering. Particular attention is called to the marked effect which the *amortisseur* of M. Leblanc has upon the parallel running of alternators, to the application of electric power to heavy railways, and to progress in contact systems for tramways. W. R. C.

1355. *Central Station Buildings.* **C. S. Peach.** (Elect. Engin. 25. pp. 309–311, March 2, and 336–340, March 9, 1900. Lecture delivered at Carpenter's Hall, March 1, 1900.)—A lecture on the subject of the architectural points necessitated by engineering considerations.

1356. *Sag of Overhead Lines.* **M. Jüllig.** (Elektrotechn. Zeitschr. 20. pp. 888–889. Dec. 21, 1899.)—From the catenary equation $y = \frac{h}{2}\left(e^{\frac{x}{h}} + e^{-\frac{x}{h}}\right) = h \cosh$ the sag and length of wire required in an overhead span between posts of unequ[al] height to give a minimum stress in the wire are calculated. A table of hyperbo[lic] functions of angles up to 4° is given, and several actual examples worked out in fu[ll]. L.

GENERATORS, MOTORS, AND TRANSFORMERS.

1357. *Commutatorless Dynamo Design.* **H. E. Heath.** (Elect. World and Engineer, 35. pp. 210–211, Feb. 10, 1900.)—For electrochemical and electrometallurgical purposes the current produced by a commutatorless dynamo is superior to that from any other form of machine. With the ordinary form of low potential dynamo the current is to an appreciable extent pulsating, owing to the few commutator segments. Three forms of commutatorless or unipolar dynamo are given, one of which is here reproduced. AA is the



armature, BB the poles, and C the exciting coil. The electrical path is shown by the continuous line, and the magnetic path by the dotted line. This machine gives 1½ volts and 9,000 amperes at 1,200 revs. The outside diameter of the armature is 15 inches, and of the pole ends 10 inches. The shaft is of Tobin bronze, to reduce the resistance, with steel collars. The loss in the field is 700 watts. The drop at full load may sometimes amount to as much as one-third of a volt, but this is apparently all in the collectors and sliding contacts. R. B. R.

1358. *Composite-Wound Polyphase Alternators.* (Amer. Electn. 12. p. 51, Jan., 1900.)—This is a description of a method employed by the Westinghouse Electric Company for compounding alternators for constant potential under varying loads. The arrangement consists of a series transformer mounted on the spokes of the armature of the alternator and rotating with it. By means of this series transformer the voltage delivered to a rectifying commutator and the fields is much less than that generated by the machine. In polyphase machines this transformer, instead of having one primary, has two or three, according to whether the machine generates two or three phases. W. G. R.

1359. *Parallel Running of Alternators.* **G. Chevrier.** (Écl. Électr. 22. pp. 401–405, March 17, 1900.)—Making use of the graphical construction suggested by C. F. Guilbert [see 1900, Abstract No. 842], the author applies

it to explain what proceedings are necessary to make the power factor for the branched circuit consisting of the alternator armatures as high as possible. In fig. 1, OC is the external current vector, OB the P.D. vector. If there is only a single alternator, then, neglecting the resistance drop, the inductance drop in its armature will be represented by BA, which is in line with CB, the inductive drop in the external circuit. BA is thus proportional to the current, and to a suitable scale represents the current vector rotated through 90° in advance of its actual position. OA gives the E.M.F. Further, the power developed by the alternator is proportional to the area of the triangle BOA, *i.e.*, since OB is constant, to PA. If there are two alternators, whose E.M.F.'s are E_1 and E_2, then (fig. 1) their currents will, to a suitable scale, be

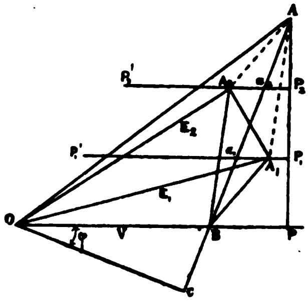


FIG. 1

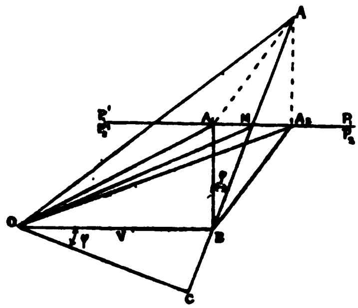


FIG 2.

represented by BA_1 and BA_2, and their powers by PP_1 and PP_2. From this it follows that if the supply of power to each alternator remains constant, and their excitations are varied, the extremities of the E.M.F. vectors will move along P_1P_1' and P_2P_2'. The best arrangement—corresponding to the least loss by heating of the alternator armatures—is obviously that for which the E.M.F.'s have the values Oa_1 and Oa_2. If the power of each alternator is the same, the diagram reduces to that shown in fig. 2, and the best arrangement corresponds to equality of the two E.M.F.'s, each of which is then equal to OM. In order to reach the point M, the alternators are first equally excited, and then the supply of power to each prime mover is adjusted until the currents become equal. A. H.

1360. *Parallel Running and Hunting of Alternators.* H. Görges. (Elektrotechn. Zeitschr. 21. pp. 188–198, March 8, 1900.)—The paper is divided into two parts. Part I. deals with the graphical representation of the E.M.F.'s currents and powers in a vector diagram. Part II. is devoted to the problem of hunting. The differential equation of the oscillations which are superposed on a uniform motion of rotation is first deduced, damping being taken into account. The author then considers (1) the natural oscillations of the alternator when displaced from its normal phase relation to the 'bus bar P.D.; (2) the forced vibrations due to fluctuations in the torque of the prime mover. Observations on actual alternators are in agreement with the results of theory. The formula deduced by the author for the natural period of vibration agrees with those previously obtained by Boucherot, Blondel, and Kapp [see 1900, Abstracts Nos. 840 and 841]. In order to avoid troublesome hunting, the author recommends the use of prime movers whose torque passes through a number of periods during each revolution. A. H.

1361. *Alternating-Current Motors.* **W. A. Layman.** (Mech. Eng. 5. pp. 80–82, Jan. 20, 128–130, Jan. 27, and 170–172, Feb. 3, 1900. Paper read before the Engineers' Club of St. Louis, and reprinted in the "Journal of the Association of Engineering Societies.")—After giving a description of induction motors in general the author proceeds to describe in detail one manufactured by the Wagner Electric Manufacturing Company of St. Louis, for which a large starting torque is claimed. In these machines the armature cores are wound with an ordinary direct-current progressive winding, connected up to a commutator in exactly the same fashion as in the direct-current motor winding. The commutator of this armature is so designed that it may be completely short-circuited by introducing a short-

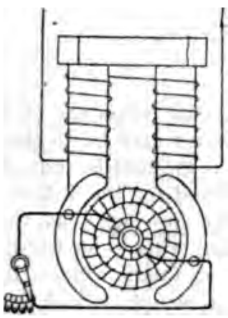


FIG. 1.

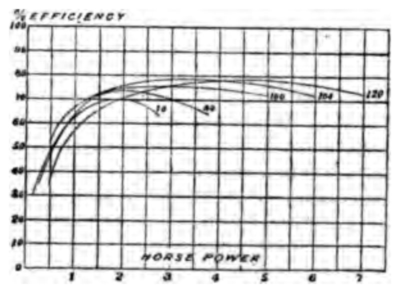


FIG. 3.

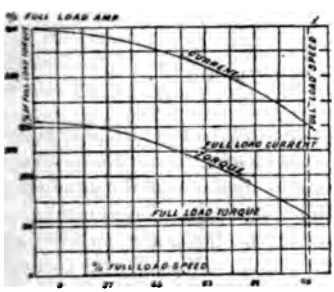


FIG. 2.

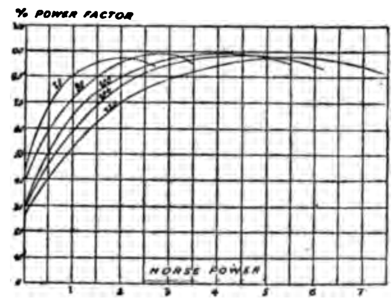


FIG. 4.

circuiting circle of copper segments. When so short-circuited this winding differs from the squirrel cage only in that, instead of the currents being left to select paths for themselves they are restricted to flowing in paths afforded by the individual coils of the armature winding. The commutator is of the radial type. The short-circuiting band is made up of small copper links, which, being mounted upon a short-circuiting ring, are thrown into an angular opening in the commutator, and by making close contact with each segment it short-circuits the whole armature. The starting arrangement is shown in fig. 1, which shows a starting resistance placed between brushes rubbing on the commutator. Figs. 2, 3, 4, show respectively the relations between starting torque and current, efficiency and load, and power factor and load. W. G. R.

1362. *Friction Losses in Induction Motors.* **F. Blanc.** (Elektrotechn. Zeitschr. 21. pp. 131–133, Feb. 15, 1900.)—Referring to Braun's article on this subject [see 1900, Abstract No. 349], the author states that the only

unsatisfactory feature about method (4) is the fact that the experimental determination of N/N_0 is very laborious if accuracy is required. He then describes the following method of finding the friction loss (this method being, however, only applicable to motors provided with slip-rings). Let w_c = copper loss, in watts, in rotor windings when the motor is loaded, w'_c = ditto when running light; w = power, in watts, employed in turning rotor; σ_0 and σ = slip of rotor, expressed as fraction of synchronous speed, when the motor is running light and loaded respectively. Then we have—

$$\frac{w_c}{w} = \frac{\sigma}{1-\sigma}$$

Now when the motor is running light, w becomes w_f, the friction loss. Hence—

$$w_f = w'_c \frac{1-\sigma_0}{\sigma_0},$$

and it remains to determine w'_c and σ_0. Since the frequency of the rotor currents is very low, the reactance of its windings may be neglected, and w'_c calculated from the formula E^2/R, where E is the E.M.F. induced in the rotor windings, and R their resistance. If E_0 stand for the E.M.F. induced in the open-circuited rotor winding between two slip-rings when the rotor is standing still, then the E.M.F. in the same portion of the rotor winding when the rotor is running with a slip σ_0 is $E_0\sigma_0$. From this it follows that if R_2 and R_3 denote the resistances of one phase of a two-phase and three-phase motor respectively—

$$w'_c = \frac{2\,E_0^2\sigma_0^2}{R_2} \text{ for a two-phase motor,}$$

and—

$$w'_c = \frac{E_0^2\sigma_0}{R_3} \text{ for a three-phase motor.}$$

In order to find σ_0, the author recommends the following extremely simple and at the same time accurate method. A small magnetic needle (a charm-compass is very suitable for this purpose) is brought near one of the conductors connecting the rotor windings to the starting resistance. The number of oscillations of the needle then gives the frequency of the rotor currents and therefore the slip. In dealing with single-phase motors, $E_0\sigma_0$ in the formulæ for w'_c must be replaced by $0{\cdot}9\ E_0\sigma_0$. In conclusion, the author gives the following formula for the friction loss, and states that it has been found applicable to motors from $\frac{1}{10}$ to 800 H.P.:

$$w_f = C\sqrt{\text{H.P.} \times D},$$

where D is the rotor diameter in cms., and C is a constant depending on the construction of the bearings and ranging from 20 to 80. A. H.

1363. *Transformers at Niagara.* (Elect. World and Engineer, 35. pp. 227–228, Feb. 10, 1900.)—A description of a set of 1875 kw. Westinghouse oil-insulated transformers, which are the largest hitherto made. They are used for transforming from 2,200 volts two-phase to 11,000 volts three-phase by Scott's method. Each measures 9 feet high by 7 feet in diameter, and weighs 30,000 lbs., including oil. The efficiency at full load is 98·5 per cent., at quarter-load 97·6, and at one-tenth load 94·6; the iron loss being 0·54 per cent., and the full load copper loss 0·96 per cent. The secondary drop at full *non-inductive* load is only 1 per cent. The 18 per cent. reduction in voltage,

required for the secondary of one transformer of a Scott-connected pair, is obtained by cutting in more turns in the primary; and in a similar way the 5 per cent. adjustment in secondary voltage, necessary for regulating with different loads, is conveniently carried out. W. H. E.

1364. *Magnetic Leakage of Induction Motors.* **M. Breslauer.** (Zeitschr. Elektrotechn., Wien, 18. pp. 99–100, Feb. 18, 1900.)—The following formulæ give the minimum power factor $\cos\phi$, the normal power current C_w, the magnetising current C_m, and the no-load current in terms of the leakage factor u for induction motors—

$$\cos\phi = \sqrt{\frac{2-u}{2+7u}},$$

$$C_o = \frac{2\,C_m}{1+u},$$

$$C_w = \frac{C_m}{1+u}\sqrt{\frac{2-u}{2u}},$$

To increase the power factor the leakage must be reduced as far as possible. Hence the modern tendency to large diameters at the expense of length in rotors. The above formulæ are compared with the results of tests of 2 and 20 H.P. induction motors which gave leakage factors of 0·11 and 0·08 and power factors of 0·84 and 0·82 respectively. L. B.

REFERENCES.

1365. *Design of Rotary Converters.* **H. F. Parshall** and **H. M. Hobart.** (Engineering, 68. pp. 721–723, Dec. 8, 783–784, Dec. 22, 1899; 69. pp. 197–198, Feb. 9, 241–244, Feb. 23, 499–501, April 20, and 535–536, April 27, 1900.)—Design of rotary converters, including that of a six-phase, 400-kw., 25-cycle, 600-volt converter (pp. 783–784); tabulated calculations and specifications for a 900-kw. three-phase rotary converter (pp. 197–198); and notes on the starting of rotary converters (pp. 241–244). [See also Abstract No. 361 (1900).]

1366. *Hutin-Leblanc Method of Compounding Induction Generators.* **Wessely.** (Zeitschr. Elektrotechn., Wien, 18. pp. 133–135. Discussion, pp. 135–136, March 11, 1900.)—A description of the devices noticed in Abstracts Nos. 620 and 908 (1899). A. H.

1367. *Dynamo Design.* **E. K. Scott.** (Elect. Rev. 46. pp. 342–345, March 2, and 429–430, March 16, 1900.)—Articles dealing with some mechanical aspects of dynamo design.

1368. *Dynamo Testing and Tending.* **N. C. Woodfin.** (Mech. Eng. 5. pp. 263–265, Feb. 24, 309–311, March 3, 351–353, March 10, and 388–390, March 17, 1900. Read before the Glasgow and West of Scotland Scientific Society, Jan. 27, 1900.)—A brief outline of the arrangements and methods employed in testing new dynamos. A. H. A.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRIC DISTRIBUTION.

1369. *Power Transmission with Constant Current.* **H. Cuénod** and **R. Thury.** (Soc. Int. Élect., Bull. 17. pp. 9–93, Jan., 1900.)—This paper describes the Thury system, and includes an account of installations where it is employed. The aggregate capacity of the plant installed since 1893 amounts to 17,500 H.P., including a 5,000-H.P., 22,000-volt plant, now under construction, to supply Lausanne from St. Maurice, 56 km. distant, where water power is to be taken from the Rhone.

The power is generated in each case by a number of direct-current dynamos connected in series according to the voltage required, and giving a constant current. The motors to be worked in the circuit are all designed to take the same current, the voltage of each depending on its output. The maximum voltage of each dynamo varies in different cases from 1,000 to 3,500, and the greatest current hitherto used is 250 amperes. The dynamos are mostly drum-wound, six-pole, and are in some cases excited independently. No trouble is experienced from sparking on the commutator, the number of segments being such that the voltage between adjacent segments does not exceed 15, in machines for the higher pressures.

When the engine or turbine is to run at a fixed speed, and the dynamos are self-excited, the current is automatically kept constant by a regulator which, between full and $\frac{3}{4}$ voltage, shunts the field, and for lower voltages moves the brushes. If separate excitation is employed, the exciter is driven by its own turbine, whose speed is automatically adjusted by the main current. Usually, however, the engine is arranged to run at a variable speed, giving a constant torque: the opposing torque varies nearly as the square of the current, and hence the current remains nearly constant. With turbines the applied torque varies with the speed, and therefore the self-regulation is not so exact. But, in either case, occasional hand regulation is sufficient; or the control may be automatic, *e.g.*, by means of a series motor carrying the main current, whose armature, resisted by a yielding spring, actuates the valves of the turbines.

Motors have their speed automatically controlled by one or more of three methods:—

(1) Regulating the field; either by a resistance in shunt or by changing the field connections so as to put some of the windings in opposition to the others. (The latter principle can be used for reversing if required.) This is the method most used, but is not suitable for motors of over 100 H.P., owing to sparking at the brushes.

(2) Changing the position of the brushes.

(3) Using secondary cells in shunt with the brushes. This method is employed only for motors under 10 or 15 H.P., preferably compound-wound. When the load is light the cells are changed, the torque being thus increased and the speed kept down. The energy stored can be used at times of heavy load.

In case of excessive speed the motor is short-circuited by a centrifugal *device. And if* the terminal voltage becomes too great (*e.g.*, by a break in the

circuit) an electromagnetic by-pass comes into action. As a protection against a very sudden rise in voltage, such as sometimes arises from atmospheric "circulatory discharges," a lightning-arrester is connected across the poles, in addition to the two between poles and earth.

The efficiency of a 800 H.P. motor was found to be 93½ per cent.

Distribution for lighting and for small motors is carried out by means of motor-generators giving constant pressure. In one case the reserve plant includes dynamos which can give either constant current (with separate excitation) or constant pressure (with shunt excitation), and can therefore be used either in the primary or the secondary, as desired. W. H. E.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

1370. *Utilisation of Schaffhausen Water Power.* **A. Amsler.** (Inst. Elect. Engin., Journ. 29. pp. 175–184. Discussion, pp. 184–191, March, 1900.) The original installation in which the power from the turbines was transmitted by wire ropes for a distance of 600 metres along the bank of the river is now being replaced by electric transmission. Owing to the wearing and loosening of the pulleys the speed of the turbines had to be reduced from 40 to 30 revolutions per minute; the average life of the ropes has latterly become less than a year, the expense of renewal being 35 per cent. of the total income.

Francis turbines are to be used driving alternators at a pressure of 2,000 volts; the power is to be delivered to consumers at a price of 125 francs a year per B.H.P. measured at the motor.

In the discussion **F. Prášil** gave an investigation of the transformer turbine in which part of the water supply is used to drive a ring of vanes intermediate between the fixed vanes and the motor wheel; an artificially increased head is thus given to the water passing through the motor wheel and the speed of the latter increased. His conclusion is that transformer turbines would only be suitable for low, variable heads and direct coupling. H. R. C.

1371. *Metropolitan Electric Supply Company's Works, Willesden.* (Electrician, 44. pp. 691–697, March 9, and 733–738, March 16, 1900.)—The load on this supply company's stations in London has grown to such an extent that it has been found necessary to increase the generating plant and also to provide for further large extensions in the future. For this purpose large works have been erected at Willesden, where a very suitable site was procured, about nine acres in extent, adjacent to the London and North-Western main railway line, a branch line of the Midland Railway, and the Grand Junction Canal. There are, consequently, ample facilities for the supply of coal either by rail or by water. The coal can be conveyed either from the canal or the railway siding by means of a conveyer, constructed by the Temperley Transporter Company, which carries coal directly into bunkers on the roof of the boiler house. The bunkers can store about 1,000 tons of coal. The coal is lifted in skips, each containing 15 cwt., to the transporter beam, a height of 55 feet. It is then carried by the traveller into the bunkers, the maximum travel being 274 feet. The full skip *en route* to the boiler house is stopped and lowered to the platform of a weighing machine; after being weighed it is again taken up and carried to the bunkers, where each skip is automatically tipped. Electrical power is used for the conveyer.

The boiler house contains sixteen Babcock-Wilcox boilers, working at 160 lbs., and fitted with Babcock-Wilcox steam superheaters. Six of the boilers

are hand fired, eight are fitted with Vicars automatic stokers, and the other two with Babcock-Wilcox chain-grate stokers. The water used is taken from the canal.

The engine-room plant consists of three large Westinghouse sets; the generators are two-phase, yield 1,500 kw. each, the pressure of each phase being 500 volts, and the frequency 60 per second, with a specified efficiency at full load of 95 per cent. The armatures were tested at 5,000 volts. The exciters are six-pole machines and yield 450 amperes at 100 volts. Each alternator and its exciter is directly coupled to a Westinghouse vertical compound enclosed marine type engine running at 116 r.p.m. There is a surface condenser placed behind each engine. These have been supplied by the Wheeler Condenser and Engineering Co., are of their Admiralty pattern, and each has a cooling service of 4,000 square feet. In connection with each is a Blake-Knowles combined air and circulating pump, the two pumps being connected to the same rocking lever. Between the engine and pump is an automatic valve operating a by-pass to an open-air exhaust if the vacuum in the condenser fails. The circulating water is cooled by three Barnard cooling towers, capable of cooling 8,000 gallons of water per hour from 130° F. to 80° F. Their dimensions are 12 ft. 3 in. × 12 ft. × 37 ft. each. The fans are driven by small Bumsted-Chandler engines. A switchboard in the engine-room forms the connecting link between the generators and the high-pressure switch-room.

The overhead travelling crane is by Higginbottom and Mannock; it has a span of 50 feet, and is rated at 35 tons, having been tested up to 50 tons. It is driven by one electric motor for all three motions.

The step-up transformers are installed in a separate room together with the high-pressure switching gear. The transformers, fourteen in number, of 250 kw. capacity each, were made by the British Electric Transformer Manufacturing Company, and are of the Berry type. The transformers for each of the two phases are independent of one another; they are not in cases, and, being thoroughly ventilated, very cool running is attained. The primary coils take 497 amperes at 523 volts, and the secondary coils yield 23 amperes at 11,000 volts. One pole of the high-pressure windings is earthed; no earth shields or earthing devices are used. The high-pressure switching gear has been designed throughout by G. W. Partridge; a fully illustrated description of it is given. On the switchboard the two phases are separated, one being brought to each side. All the outer conductors of the concentric mains are coupled together and earthed. Two fuses in parallel are used in each case, one only being used for light loads; the second fuse is put in circuit as the load gets heavier. The fuses are of tinned copper wires in stoneware tubes 4 ft. 6 in. long. The mains are not switched directly on to the transformers; the circuit is first closed through the primary of a charging transformer placed in series with the main transformers, the secondary of the charging transformer being on open circuit; the resistance of this secondary is gradually cut down by means of a water rheostat, the main fuse being eventually put in, and the charging transformer cut out. In switching off the mains the reverse operation takes place.

There are two trunk mains, one for each phase, consisting each of paper-insulated concentric cables, and also an extra one laid alongside as a spare main. The mains are laid under the canal towpath in a cast-iron channel of five ways, with a loose cast-iron lid; full descriptions are given of the disconnection boxes and of the jointing and laying of the cables. At the *substations* the pressure is reduced to 1,000 volts. The switch gear is similar

to that employed at Willesden; all pressure regulation is done in the sub-stations. There are also a small test transformer and suitable plug switches on the board, for the purpose of ascertaining on which side of the system the extra main has been placed at Willesden in the event of the spare main being required.

The article is fully illustrated, and a complete account is given of the scheme. E. D. P.

1372. *Polyphase Distributing System of the Metropolitan Street Railway Company of New York City.* **J. E. Woodbridge.** (Elect. World and Engineer, 35. pp. 463–464, March 31; 501–504, April 7; 541–544, April 14; 579–581, April 21; 613–615, April 28; and 698–701, May 12, 1900.)—The lines owned, leased, or operated by the Metropolitan Co. aggregate about 217 miles of track, of which 82 miles is at present worked electrically. Quite recently the Whitney Syndicate which controls the Metropolitan Co. has obtained a controlling interest in the Third Avenue Railway Co. (58 miles of track), and the Union Railway Co. (55 miles of track), so that altogether the lines which will be operated from the station now approaching completion will in about a year have 3,000 cars in their sheds, or about 1,500 in actual operation at one time.

The generating plant will, when completed, consist of eleven main engines each rated at 4,500 H.P. with cut-off at maximum economy, but capable of working up to 7,000 to 7,500 H.P. apiece.

The following are the leading particulars of the eleven three-phase generators:—

Type: Revolving field with external stationary armature mounted between the two halves of the vertical engine.

Output: 3,500 kw. normal, or 5,000 kw. for four hours; voltage, 6,600; frequency, 25; speed, 75.

Shaft: Compressed steel 37 inches diameter, being the crank-shaft of the engine, the spider secured by two keys each 5 in. × 2½ in. section.

Spider of the field ring has eight arms cast in one piece with the hubs, the fly-wheel hub being bolted up *direct to the arms* by sixteen 2½-inch bolts at a distance of 4 feet from shaft centre.

Field Ring of cast steel in four sections, each half the full axial width of the ring, and each spanning half the circumference. The rim tension of these rings is carried across the butt joints by means of double-headed keys similar to those commonly used in fly-wheels.

Poles: 40 in number made of laminated steel with an edgewise winding. Overall diameter 16 ft. 8 in., giving a peripheral speed of 3,900 feet per minute.

Excitation: The exciting current at 100 to 125 volts is introduced to the revolving field coils by carbon brushes bearing on *cast-iron* rings. The resistance of the field is ⅓ ohm, the necessary exciting current for full voltage from the armature (6,600) with non-inductive load being 300 amperes.

Air-gap: $\frac{3}{16}$ inch at pole centre, to $\frac{11}{16}$ inch at the tips. It is purposely made narrow, and the magnetism has been carried fairly high on the saturation curve, because by working at a high line-density the magneto-motive force of the armature reaction is unable to cause as great a change of the field strength as it would if this density were down on a steeper portion of the magnetisation curve. On this account the throwing off of the full non-inductive load causes a rise in voltage of only 5 per cent. The short air-gap reduces the number of necessary field ampere-turns, to which the

armature short-circuit current is directly proportional, thus cutting down the latter to the low figure of rather less than 800 amperes per leg, the rated full-load current being slightly over 300 amperes.

Armature ring of cast iron, 21½ feet external diameter, mounted on sliding foundation plates so that it can be moved axially to clear the field.

Armature coil built up of laminated steel with eight ventilation spaces. The core bolts do *not* pass through the plates.

Armature winding: On account of the high potential, 6,000 to 6,600 volts, the winding is carried in a few large slots per pole rather than a large number of small ones. There are six slots per pole, two per pole per phase, each 1¾ in. × 3¾ in., deep, and containing former-wound coils, the ends of all coils of two of the phases being bent back to clear those of the third phase, making what is known as the double-chain winding. The connections are such that all the turns of each phase are in series with each other, the three phases being **Y** connected.

Efficiencies: 1¼ load, 97 per cent.; full load, 96·7 per cent.; ¾ load, 96·2 per cent.; ½ load, 94·8 per cent.; ¼ load, 90·8 per cent.

Weight: The complete machine weighs 130 tons, the rotating part accounting for about half of this.

The designers appreciated the risks that would accrue were 6,600 volts allowed to concentrate itself on a single fault. On account of this and the widespread character of the public service which would be interrupted by a shut down, all routes over which the power is carried from part to part of the station, as well as from it to the substation, is divided as much as possible. For instance, the conduits which carry the cables from the generators to the switchboard gallery are several in number, and widely separated from each other, the same being true of the vertical cable ducts. Again, although for convenience of operation there is one switchboard, yet much trouble has been taken to distribute the switching apparatus itself over a much greater area than would, for purely mechanical reasons, be necessary. Thus each switch and each pole of each switch or circuit-breaker is placed within its own cell, separated by brick walls from the other cells, and by double brick walls and intervening air spaces from other switches or circuit-breakers.

The circuit-breaker is of the oil type and is operated by compressed air forcing a piston up or down in a vertical cylinder above the top of the brick structure, enclosing the live parts. The valve controlling this cylinder is operated by one magnet. When the magnet is excited and draws its armature down, it pulls a valve—which is a miniature of the plain unbalanced **D** valves of simple engines—into such a position as to admit air above the piston and exhaust it below, thus forcing the piston down and closing the main current contacts. If current is cut off from the magnet by any means the valve is instantly restored by a spring into such a position as to admit air below the piston and so open the contacts. The magnet is wound with two coils, one of fine and one of coarse wire connected in series with each other. The movement of the armature works an automatic switch which short-circuits the high resistance part of the winding when the armature is up, thus allowing a powerful current to pass from the constant potential source of supply to draw the armature down with plenty of reserve force. As soon as the armature is down, the increased resistance thrown on by the automatic switch reduces the flow of current through the magnet winding to an amount only sufficient to hold the armature in the down position, thus economising current which must be left on as long as the oil circuit-breaker is closed. The exciting current is at 110 volts, and the com-

pressed air for the pneumatic cylinders is supplied by motor-driven air-pumps with automatic controllers.

Comparisons are made between the new type of circuit-breaker and the old type in which three magnets were used. A description is given of the automatic controlling switch with differential magnet for reverse current protection; and also a detailed account of the method of arranging the 'bus bars and various circuits on the switchboard. Numerous illustrations and diagrams are given.

The last and sixth article deals with the high-tension feeders and the substations. The feeders are triple conductor cables, each conductor having a cross section equivalent to 4/0. Each cable end is flared out to bell-mouth form to prevent static discharges from piercing the insulation at this point, and static dischargers (which are the same as lightning arresters) are also connected to each end. At the generating station the circuit-breaker, through which the current passes to the feeder, is fitted with an automatic overload relay, and again at the substation the circuit-breaker is fitted with an automatic releasing device actuated by a reverse current relay. In case a short occurs on any feeder, there will be a rush of current into it from the generators which will operate the overload relay, and at the same time the rush of power back into the other end of the feeder from the substation 'bus bars, operates the reverse current relay. In this way the feeders are at once cut out of circuit at both ends.

There are six substations, each with from three to six 1,000-kw. rotary converters. The step-down transformers—three to each converter—are of the air-blast type, and reduce the voltage from 6,000 to 350. [See also following Abstract.] E. K. S.

1373. *Power Stations of Metropolitan Co. and Third Avenue Railroad Co., New York.* (Tram. Rly. World, 9. pp. 57–61, Feb., 1900.)—*Metropolitan Company.*—System: Conduit, three-phase distribution. The boiler-room contains forty-eight Babcock boilers on three floors. Each boiler has 2665 square feet heating surface, 160 lbs. pressure. Coal is stored in two 5,000-ton bunkers by boat-unloading and conveying machinery. It is delivered into mechanical stokers through shutes. The engine-room contains eleven 6,000 I.H.P. Allis vertical cross-compound Corliss condensing engines, having cylinders 46 inches and 86 inches in diameter, 60-inch stroke, running at 75 r.p.m. Each engine drives directly a G.E. 3,500 kw. stationary armature three-phase 6,600 volt generator. Each of the five substations contains 350-kw. step-down transformers, and 990-kw. rotary converters transforming to a pressure of 550 volts. The substation capacity ranges from 3,000 to 5,000 kw., which it is subsequently proposed to increase by the use of accumulators. The conduit system will be in use on 220 miles of track. Drawings: Scale plan, and section of generating station. [See also preceding Abstract.]

Third Avenue Railroad Company.—System: Conduit. The boiler-room will contain sixty Babcock boilers on two floors. Working pressure 200 lbs. Coal will be stored in a bin of 10,000 tons capacity, and fed through mechanical stokers. The engine-room will contain nearly 100,000 H.P. of 7,000-H.P. vertical cross-compound condensing Westinghouse engines, having cylinders 48 inches and 86 inches diameter, 60-inch stroke, running at 75 r.p.m. Drawings: Scale plan of generating station. J. T. R.

1374. *Fremont Three-phase Railway, Ohio.* (Street Rly. Journ. 16. pp. 227–231, March, 1900.)—This is a description of the long-distance, electric, high-

speed railway between Toledo and Norwalk. The entire length of the line—sixty miles—will be supplied with current from a central power station at Fremont, from which current will be transmitted at high pressure, thirty miles in each direction, to six substations, where it will be transformed down and converted to direct current for feeding the trolley lines. The boiler house contains five Babcock-Wilcox boilers, each of 300 H.P. nominal rating and working at a pressure of 155 lbs. per square inch. The feed water is pumped from the Sandusky River through one 6-inch and two 14-inch pipes. Two Worthington pumps lift the water from the intake well to two elevated jet condensers which are set over a single hot well. The feed water is taken from this hot well by a Worthington tank-pump to the treating plant. When neither of the condensers are running, the feed water is drawn direct from the river through the 6-inch suction-pipe by the Worthington tank-pump ; or should this pump be disabled, the feed-pump can draw the water from the river well direct through the same 6-inch pipe. The water is treated in two large tanks provided with stirrers worked by electrical power. It is afterwards run into a large filter tank, constructed of Portland cement masonry, which is fitted with a sand filter bed, aluminium-bronze strainers, washing pipes and stirring devices. After leaving the feed-pumps the water passes through an auxiliary heater, where it receives the surplus heat of the auxiliary pumps and engines, thence through an economiser to the boilers. The feed-piping is so arranged that either the heater or economiser may be by-passed. There is coal storage above of 500 tons capacity from which the coal is fed by gravity to the mechanical stokers. The ashes and refuse are also conveyed mechanically to a bin. A branch line of the Wheeling and Lake Erie Railway passes under the refuse bin, and also over the coal-handling plant, which consists of an endless chain of wheel and pan construction. The coal and ash handling machinery is operated by a 10 H.P. Westinghouse Standard engine. Draught is furnished by two vertical discharge fans, directly connected to horizontal engines, which are fitted with a regulator whereby the speed is increased as the steam pressure falls, and *vice versâ.*

A compressed-air system has been installed for cleaning the electrical machinery. It consists of a Westinghouse Air Brake Company's standard air-pump, storage tank, &c. Four 1,000-H.P. vertical compound engines are to be installed, having steam cylinders of 21·5 in., and 37 in. × 22 in. stroke, and running at 214 r.p.m. Each of these Westinghouse engines is directly coupled to a 500-kw. Westinghouse three-phase generator. Special devices are to be provided to enable the speed of any engine to be varied from the switchboard. Excitation is provided by two 30-kw. direct coupled Westinghouse sets. Each of these sets is capable of supplying the main generators d the works lights.

The transformer room is under the engine-room, and will be equipped two banks of three transformers, each of 400-kw. of the Westinghouse oilated self-cooling type. There will also be two 200-kw. Westinghouse rotaonverters installed at the generating station, taking current from the main bars to supply the contiguous sections of the line. The whole system, h the main generators and the substation plant will be arranged for paralrunning. The switchboard arrangements are of the usual kind. Time-elem circuit-breakers are installed. The pressure of the main transmission threphase line is 16,000 volts ; each wire is protected by a 16,000-volts Wurts lightng arrester. Each of the six substations contains two 200-kw. Westinghouseonverters and three 150-kw. step-down transformers. Loops are brought t of these transformers to effect different ratios of trans-

formation, so that the pressure on the trolley line may be equalised in different substations. The high tension current is carried by three bare copper wires, one upon each end of a cross arm and the other on the top of the pole. Six feet below the cross-bar is the bracket carrying the trolley wires. On the opposite side of the pole, just above the bracket, are carried the direct current feeder cables. The track is single, with turnouts. Cedar ties are used, ballasted with gravel and stone; Carnegie 75-lb. T rails, Forest City Electric Co. bonds, and cross-bonds every 500 feet are employed. The passenger cars are equipped with two 75-H.P. Westinghouse railway motors, sufficient for a speed of 50 miles an hour on a straight, level track, and are fitted with Westinghouse air brakes. The car bodies are mounted on the Barney and Smith improved Class F truck, especially designed for heavy work. Spoke wheels, 36 inches diameter, will be used with axles of hammered iron 5·875 inches diameter. The cars have a seating capacity for 50 passengers. The substations along the line will serve as points for the collection and distribution of freight. Mileage books for 1,000 miles will be sold for 12·50 dollars, and the local fares will be about one-half of those charged by the steam railroad. E. D. P.

1375. *Exeter-Amesbury Railway, U.S.A.* (Street Rly. Journ. 16. pp. 232–234, March, 1900.)—An illustrated description of the electric railway laid along the highway between Exeter and Amesbury, a distance of twenty miles. The generating station is at Hampton. The boiler-room contains three Ames' horizontal tubular boilers of 125-H.P. each, and one 150-H.P. Dillon boiler. Water is drawn from an artesian well 154 feet deep. The feed-water heater is of the Lamphear compound type, in which the auxiliary heater is placed inside the primary heater. The feed-water is passed into the primary heater coils receiving the heat due to the exhaust steam of the engines exhausting into the condenser. This temperature is about 120°–130° F. At the opposite end from which the water enters, it passes into the auxiliary heater, through a lower set of tubes to a settling chamber, then through the upper set of tubes to another chamber, and thence to the boilers. The auxiliary heater receives the exhaust steam of the pumps at the top, whence it passes down round the tubes and out to the atmosphere or the hot well. It is seldom that any steam is seen coming from this outlet, the condensation in the heater being so effective. The temperature of the feed water from the heater, at a distance of 12¼ feet, with everything running, is about 210°–212° F. The pumps and condenser, 800 H.P., are all of the Davidson make. The engine-room contains one cross-compound Buckeye engine, cylinders 16·5 in. and 30·5 in. × 30 in. stroke, 350 H.P., directly coupled to a G.E. generator of 250 kw., running at 120 r.p.m. Also two simple Buckeye engines, cylinder 15·25 in. × 24 in. stroke, 180 H.P., running at 160 r.p.m., and belt coupled to two Keystone generators of 125 H.P. each. In addition, for lighting purposes, there is a tandem compound Buckeye engine, 175 H.P., driving by belts an 80 arc light Brush machine and a G.E. alternator of 1,500 lamps capacity. The car house, 250 ft. × 50 ft., is separate, and can accommodate twenty-four cars. In the rear are six pits with brick sides and cement bottoms, and in the front is a cement floor where the cars are washed. At the rear of the car house and separated from it by a fireproof wall is a repair shop and stock-room. The overhead line is mostly of the side pole construction, with Creaghead flexible brackets. The track is of T rails. The rolling stock consists of eight fourteen-bench open cars, ten ten-bench

open cars, nine closed cars, and two freight cars, also several Taunton ploughs. Two motors of 35 H.P. each are used on the ten-bench cars, and two 50-H.P. motors on the closed cars. The car trucks are of the Dupont make. There is a branch line to Hampton Beach, a popular pleasure resort. E. D. P.

1376. *A Hill-side Electric Tramway, near Rouen.* (Tram. Rly. World, 9. pp. 109–112, March, 1900.)—System: Overhead trolley, continuous current. The boiler-room contains two Babcock boilers with a heating surface of 1,830 square feet, 176 lbs. working pressure. The engine-room contains two 200-H.P. horizontal condensing engines, having 16 ft. 4 in. flywheels weighing sixteen tons, and running at 200 r.p.m. Each engine drives by a leather belt a 150-k.w. 560-volt Westinghouse generator. Rain water is collected in reservoirs for condensing, and is returned after passing through water coolers. Along the track, wood, and in the town, iron, poles carry by means of span wires, and at some points brackets, a $\frac{3}{8}$ in. trolley wire 21 ft. 3 in. above the track. The rails are of grooved girder type 83 lbs. per metre on public roads, and 56-lb. tee rails elsewhere. The track is single, with passing places 500 metres long. There are six closed motor cars mounted on Peckham trucks, each fitted with two 35-H.P. Westinghouse motors. There are six open trailers. The motor cars and trailers combined have a capacity of forty-eight passengers. In order to avoid steep gradients, costly retaining walls and cuttings have been constructed. The cars are not fitted with special power brakes. J. T. R.

1377. *Electric Railways in Italy.* **K. Neudeck.** (Zeitschr. Elektrotechn., Wien, 18. pp. 106–107, Feb. 25, and 116–118, March 4, 1900.)—Particulars are given of the Monza-Milan line worked by accumulators, the Milan-Leveno-Varise line, which is to be 112 km. long, and the Bologna-San Felice line, 42 km. long. This article is, however, principally interesting because of particulars which it gives of the Lecco-Colico-Londrio-Chiavenna line, 116 km. long, which Ganz and Co., of Buda-Pesth, are now equipping for the Adriatic Railway Company. This line is to be operated by three-phase currents generated at the power station on the River Adda at 15,000 volts, and transformed down to 3,000 volts on the trolley wires. The two trolley lines (the rails form the third conductor) are spaced 3 feet apart, and they are fed with current from substations, which are 10 km. apart. The line is divided into sections, each being supplied with current from the substation next beyond it. This gives great safety in working, for when a block signal indicates "Stop," the next part of the line is not supplied with current. Moreover, in case of interruption of current the Westinghouse brakes come on automatically.

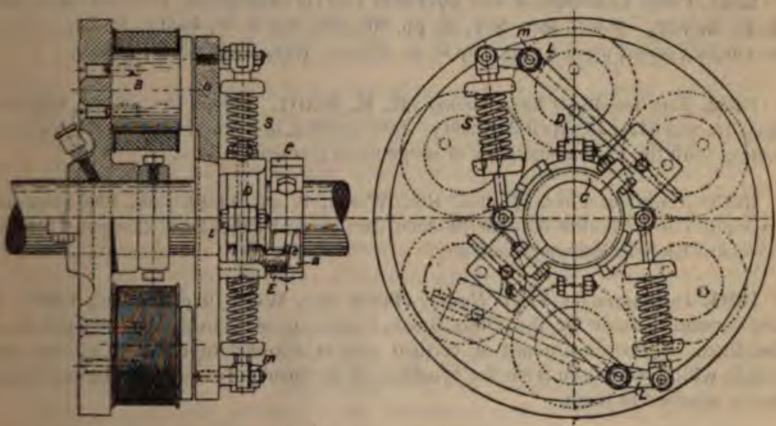
The passenger trains consist of one motor car and one trailer. Each motor car has four motors, but is usually driven by only two, the normal speeds being 60 and 30 km. per hour, according to whether the train is on the level or on a gradient. The freight trains have a maximum capacity of 200 tons, and are hauled by a locomotive car. They run at 30 and 15 km. per hour. E. K. S.

ELECTRIC TRACTION AND AUTOMOBILISM.

1378. *Buffer Batteries for Electric Traction.* **E. Sieg.** (Elekt. Runds. 17. pp. 91–92, Feb. 1, p. 105, Feb. 15, 1900; Elektrotechn. Zeitschr. 21. pp. 226–228, March 15, 1900. Paper read before the Elektrotechnische Gesellschaft

of Cologne.)—The effect of buffer batteries in electric traction systems in equalising the dynamo load with the consequent saving in capital expenditure and in wear and tear in the machinery is explained. Such batteries were first employed at Zurich in 1893 and Remschied in 1895, and are now becoming general in Continental traction stations. In the Remschied station the battery of 260 ampere-hour capacity reduced the maximum dynamo output from 190 to 95 amperes, and the variation in voltage on the 600-volt line from 200 to 37 volts. The larger the capacity and the lower the internal resistance of the battery the more perfect is its steadying effect. The resistance lies mainly in the electrolyte, the drop in voltage in each cell due to this resistance being 0·0015 × distance between the plates (m.m.) × current density in amperes per square decimetre. As the discharge proceeds the resistance of the active materials rises with corresponding drop in the terminal voltage. By means of a subsidiary electrode the seat of the potential drop can be determined, and curves of this drop traced for various discharge rates. The effect of form of plate on this potential drop is discussed. The diagrams and curves accompanying the original paper are reproduced in the Elektrotechn. Zeitschrift only. L. B.

1379. *Electric Brake.* (Tram. Rly. World, 9. pp. 66–67, Feb., 1900.) —The Helios Electrical Company of Cologne has introduced a brake on the Landsberg cars, in which use is made of Foucault currents. The cars have a motor on one axle and the brake on the other, the latter being used only to check the motion, and so prevent wear and tear on the brake shoes, and wheel tyres. A mechanical brake comes into use to bring the car to a stand-



still. The electric brake consists of two chief parts—the electromagnets, B, which are prevented from rotating by being fixed to the truck, and the armature, *a*, which is keyed upon the axle in such a way that while it rotates it may have at the same time a slight horizontal movement along the axle. This horizontal movement is effected by means of fly weights attached to the levers L, which open and close according to the speed of the axle, a projection E on the ring D engaging with the inclined grooves *c* of the ring C.

The brake magnets are excited by the motor, which acts temporarily as a generator; thus both axles are braked, the one by the motor acting as a generator, and the other by Foucault currents engendered in the armature

of the braking apparatus. When the brake is first applied the exciting current in the brake magnets is relatively strong, but as the speed of the car decreases, it falls off; at the same time, however, the flyweights close in towards the axle, and thus cause the armature to approach the pole-pieces, so that the air space, and therefore the magnetic resistance, being diminished, the efficiency of the brake, compared to the first effect obtained, remains nearly the same. It may be mentioned that the effect obtained by the mechanical action of the flyweights is assisted by the action of the Foucault currents, giving an effect during the decrease in speed, which is in the same direction as the displacement. E. K. S.

1380. *Trolley Motor Car.* **É. Hospitalier.** (Ind. Élect. 9. pp. 45–48, Feb. 10, 1900.)—For extensions to tramways and on country routes, which cannot afford the capital expenditure necessary for track, Lombard-Gerin suggests a double trolley line, along which there runs a small motor connected to the car by a flexible extensible cable. The current which propels the trolley motor is derived from the motor on the car, and its speed depends on the speed of the car. The trolley and motor weigh 18 kgs., and take at top speed 500 watts. The trolley motor is actuated by three-phase currents taken off the direct-current motor. M. O'G.

REFERENCES.

1381. *Power Consumption and Operative Costs of Automobile Delivery Waggons.* **G. F. Sever.** (Elect. Rev. N.Y. 36. pp. 307–308, March 28, 1900.)—Remarks upon the subject, based upon a paper by R. A. Fliess. (See 1900, Abstract 950.)

1382. *Traction-Motor Suspensions.* **E. K. Scott.** (Elect. Rev. 46. pp. 603–605, April 13, and 647–648, April 20, 1900.)—Two articles, illustrated by several drawings, dealing with the various methods of suspending tramcar motors.

1383. *American Cars.* (Tram. Rly. World, 9. pp. 12–13, Jan., 1900.)—A full description of the bodies of some modern cars made by the Brill Company for the Cleveland Electric Railway Company.

1384. *Insulators for Third Rails.* (Tram. Rly. World, 9. p. 13, Jan., 1900.)—A new insulator, made by the Ohio Brass Company, of Mansfield, Ohio, U.S.A., is described. A certain amount of vertical play is allowed in order to obviate the trouble which has arisen from the breakage of the insulators owing to the rail being rigidly attached to them.

1385. *Electrical Driving of Factories.* **A. H. Gibbings.** (Elect. Rev. 46. pp. 551–555, March 30, 1900. Paper read before the Northern Society of Electrical Engineers, Manchester, March 13, 1900.)—This paper contains two tables of interest. The first gives the number of motors on the circuits of a large number of towns in England, together with the number of units sold for motor purposes by each; and the second gives some tabulated particulars about thirty motor installations in Bradford, showing that in general motors have been found to be cheaper than gas engines.

1386. *Electric Lighting Cable Breakdowns.* **G. Kapp.** (Elect. Rev. 46. pp. 380–383, March 9, and 471–473, March 23, 1900.)—Translation of paper referred to in Abstract No. 755 (1900).

TELEGRAPHY AND TELEPHONY.

1387. *Improvements in Wheatstone's Automatic Telegraph.* (Elect. Rev. 46. pp. 340–341, March 2, 1900.)—This article describes improvements in the transmitter and the perforators, by J. Willmot. In the former the contact lever, instead of being held over to the contact-points by means of a spring and jockey roller operating upon the end of the lever, which arrangement required a large play of the lever and much downward pressure, as well as the use of a lubricant, which is objectionable in the neighbourhood of electrical contacts, is retained in place by a permanent magnet, which is said to obviate these difficulties. The force necessary to drive the instrument is also less. Improvements in pivotting of the crank levers and horizontal levers are also detailed. The punch of the perforator has hitherto suffered much wear by the deposits of oil from the paper giving it a convex form, and the cut-out portion being thus bent over the edge of the punch. The cut paper is also from this cause sluggish in dropping out. Willmott's new punch has a hollow recess at its end, and makes a clean perforation; being hollow, it is more easily ground, and while a perforation is being effected the air within the hollow is compressed, and then tends to blow away the piece of paper the punch has removed. E. O. W.

1388. *Multiplex Telegraphy by the Telemicrophonic Relay.* **E. Mercadier.** (Comptes Rendus, 130. pp. 770–773, March 19, 1900.) A description of the author's "Monotelephones," or telephones "tuned" to certain periodicities, has been already given [see 1899, Abstract No. 1995]. In this system the apparatus permits of upwards of twenty-four transmissions being simultaneously effected over one circuit. The receivers are, as before, telephones tuned, so that each will respond only to a current of a certain period, notwithstanding that currents of other periods are present in the circuit. His telemicrophonic and differential relay is designed to magnify this effect, and to permit of sending and receiving simultaneously. He employs currents, undulating and sinusoidal, varying in period from $\frac{1}{450}$ to $\frac{1}{800}$ of a second by half-tones. A diaphragm 10 cm. in diameter vibrates in front of an electromagnet, which is differentially wound, and which occupies the place of the relay in the ordinary systems of duplex telegraphy; the line is balanced in the usual way. A little plate of carbon is fixed to the centre of the outside of the diaphragm, and another piece of carbon, attached to a metal stud at the extremity of a long, thin, vertical spring, completes the microphonic contact. This contact, with the spring and the diaphragm, are in circuit with a battery and the primary of an induction coil, and it is, of course, actuated when the diaphragm moves under the influence of undulatory currents arriving from a distant station. The twelve receivers are in circuit with the secondary of the coil, and are, as has been stated above, "tuned," so as to be selective of that one current which has the appropriate periodicity. The microphonic, or rubbing carbon contact, reproduces the effects of all the undulatory currents that are flowing in the one circuit. Screws regulate the distance of the diaphragm from the electromagnet, and also the pressure of the carbon contact. The system has been practically tried on circuits of 600 to 800 km. in length, and is evidently adapted either for two or more than two stations by intercalation in series or in derivation, upon any circuit where a telephone can work. E. O. W.

1389. *Snow on Phosphor Bronze Wires.* **E. Piérard.** (Soc. Belge. Élect., Bull. 17. pp. 52–55, Jan., 1900.)—On short lengths the weight of snow may be twice or even four times the weight of the wire, and thus reach the breaking point. On lengths of 500 metres, however, the wire would stretch to the roof or ground, and hence would never break from this cause. M. O'G.

1390. *Ducousso's Telephone Switchboards.* **L. Montillot.** (Électricien, 19. pp. 177–181, March 24, 1900.)—These are arranged in two ways. In the one the operator is able to place the Exchange telephone in derivation during a conversation, and in the other, or "secret" system, the operator cannot do so. Each line has its own indicator, calling-key, jack, cord, and plug peculiar to itself. In the first system the operator has a plug and cord connected to her apparatus; in the second system these attachments are dispensed with and the apparatus is connected to a jack on the board. On the one hand, therefore, she is able to answer a call, or to listen to a communication, to put her plug in any jack on the board; but, on the other hand, in the "secret" system, she must, to answer a call, put the subscriber's plug with its cord attached into her own jack, and, having ascertained what is wanted, remove the same plug and insert it in the jack of the line required. She is thus cut off from the circuit being used. But the cord and plug of the subscriber called are still hanging idle and might, with the ordinary connections, be used by the operator in her own jack to overhear a conversation. This is rendered impossible by so arranging the springs of each jack that, upon the insertion of a plug, the jack's own plug is cut out of connection.

A commutator or switch is mounted upon the board by which one of three connections of the ringing circuit is effected; that is, when a subscriber calls there is a continuous ringing, a momentary ring, or none at all, the only indication in this last case being the fall of the drop. E. O. W.

1391. *Underground Telephone and Telegraph Work.* (West. Electn. 26. pp. 159–160, March 17, 1900.)—A description with plan and illustrations of the tunnel work in Chicago of the Illinois Company. The tunnels are 8 feet high with a maximum width of 6 feet. The floors are 33 feet below the surface of the streets, so that by means of shafts here and there throughout the city work is carried on with no disturbance of public traffic. To keep the earth from falling in as the drifts are advanced, all the work is done under an air pressure of about 10 lbs. above the atmosphere, the usual air locks being provided. Lateral tunnels branch off to buildings underneath the pavements and rise to the surface without manholes in the streets. The laterals are 3 feet in diameter. Both tunnels and laterals are lined with Portland cement, the former for 10 inches and the latter for 8 inches of thickness. All wires and cables will be carried on racks at the sides. The temperature in the tunnels varies from about 75° to 80° F. The lighting is by incandescent electric lamps, naked lights being avoided owing to danger from gas leaks. The bottoms of the drifts are graded to carry off moisture, of which there is very little at present, but if it collects it will be pumped out. The tunnels are said to be the only ones of their kind constructed entirely of cement. The Exchange system is to be automatic, for which no help is required at the central. It is said to afford entirely secret communication. The company intends to wire all buildings with which it deals, so that a telephone can be put in each room, and to furnish instruments on a meter system, at a charge of 5 cents for each call above the ordinary subscription up to a maximum, with the latter, of $85. It is estimated that 50,000 telephones can be thus supplied in Chicago. E. O. W.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

JULY 1900.

GENERAL PHYSICS.

1392. *Bending Modulus of Beeswax and Paraffin.* **M. S. Segel.** (Phys. Zeitschr. 1. pp. 126–127, 1899. Communicated by the Physikalischen Institute der Universität Kasan.)—Interference bands are used in measuring the bending of short beams of the substances. The plastic effect is very large, and Young's Modulus, calculated from the elastic effect is found to vary from 223·4 kg/mm² at 5° to 127·4 kg/mm² at 28° in paraffin, and from 59·1 kg/mm² at 11·5° to 46·6 kg/mm² at 19·4° in wax. G. E. A.

1393. *Hoop Stresses and Tensile Strength.* **M. Grübler.** (Phys. Zeitschr. 1. pp. 190–191, Jan. 20, 1900. Report read before the 71st. Naturforscherversammlung in Munich.)—In testing hollow cylinders of white sandstone to destruction by rotation at high speeds, the hoop stress was on the average 51·5 kg. per sq. cm. With this material the modulus of elasticity is practically constant up to the breaking point. Careful tensile tests on the same material gave a strength of 21·6 kg. per sq. cm. The great discrepancy between these two results is, in the opinion of the author, due to imperfections in loading the tensile test specimens uniformly. The theory of the stresses in a rotating disc shows that if a small hole be drilled at the centre of the disc, the stress is double that in a complete disc rotating at the same speed; wherefore the bursting speed of rotation of the complete disc should be $\sqrt{2}$ times that of the perforated disc. Tests of hollow cylinders and solid cylinders of white sandstone, however, showed that they burst at practically the same speeds. A. S.

1394. *Calibration of a Glass Tube and Compressibility Coefficients.* **G. A. Hulett.** (Zeitschr. Phys. Chem. 33. pp. 237–244, April 17, 1900.)—The author's method of calibration, which is quicker than, and obviates the troublesome calculation required by, the ordinary method, is as follows: The tube is filled to the zero point of the scale with mercury, which is then kept in a fixed position by closing the lower end of the tube. By means of a narrow capillary pipette successive equal volumes of mercury are removed, the various positions of the meniscus being read off. From the number of the reading and the total amount of mercury taken away the corrections for

irregularity of the tube are calculated. For internal diameters less than 0·50 mm., the method is difficult to carry out.

Taking Amagat's value, 39×10^{-7}, for the absolute compressibility of mercury for 1 atmosphere, the author finds the following numbers for the compressibility of water saturated with air. At 9°, $45·3.10^{-6}$; at 17°, $44·6.10^{-6}$; at 50°, $41·9.10^{-6}$. For paratoluidine at 45° the value is $51·2.10^{-6}$.
T. H. P.

1395. *Thermal Deformation of a Balance.* **T. Middel.** (Ann. d. Physik, 2. 1. pp. 115–134, May, 1900.)—In their determination of the gravitational constant in the citadel of Spandau, Richarz, and Krigar-Menzel observed strong variations of the sensitiveness of their balance. The author shows that these variations were due to the unequal thermal expansion of the parts of the balance beam, some of which were made of rolled brass, while the others were made of cast brass. He tested the beam used by those experimenters, and proved by means of two mirrors attached to the ends and at right angles to the beam that the beam was bent by a rise of temperature, as indicated by an increase in the angle between the two mirrors. The rolled brass has a higher coefficient of expansion than the cast brass. No additional error is introduced by placing the weights on the balance. Moreover, a few oscillations of the temperature suffice to annul the bending. E. E. F.

1396. *Stereoscopic Rangefinder.* **C. Pulfrich.** (Phys. Zeitschr. 1. pp. 98–102; Discussion, pp. 102–104, 1899. Report read before the Naturforscher-versammlung in Munich.)—The rangefinder which this paper deals with is the one now made by Zeiss of Jena, the original idea and fundamental design emanating from the late H. de Grousilliers.

The instrument consists essentially of a Helmholtz "Telesterescope," with scales introduced in the two eyepieces. These two scales are so graduated and so arranged that when viewed simultaneously in the eyepieces with the two eyes, the two scales seem to combine and to represent one scale stretching from the observer away to an infinite distance in the landscape. To find the range of any object it remains only to judge which mark on the scale seems to be at the same distance as the object is from the observer.

The accuracies claimed for the different sizes of instrument are as follows:—

Range.	I. Magn. = 8. Base = 50 cm.	II. Magn. = 14. Base = 87 cm.	III. Magn. = 23. Base = 144 cm.
500 m.	9 m.	3 m.	—
1,000 m.	35 m.	12 m.	5 m.
2,000 m.	141 m.	50 m.	18 m.
4,000 m.	564 m.	200 m.	70 m.
8,000 m.	— m.	800 m.	280 m.

J. B. H.

1397. *Water-Bath Regulator.* **H. S. Hatfield.** (Chem. News, 81. p. 6[illegible] Feb. 9, 1900.)—The water supply-tube bifurcates, one limb dipping under th[illegible] water in the bath, whilst the other, by which the excess of water escapes, h[illegible] an opening in its side at the desired height. The apparatus possesses [illegible] advantage over other regulators in that its action is not affected by [illegible] collection of air-bubbles, which are immediately carried away by the curr[illegible] of water. N.

1398. *A Manostat.* **A. Smits.** (Zeitschr. Phys. Chem. 33. pp. 39–46, April 3, 1900. Paper read before the Koninklijke Akademie van Wetenschappen, Amsterdam, Nov. 27, 1897.)—The results of ebullioscopic experiments are often seriously affected by alterations in the atmospheric pressure during the progress of the work. The author has therefore devised an apparatus (manostat) whereby the pressure is maintained constant to within less than 1 mm. of water. It consists essentially of a manometer connected with an electrical mechanism by means of which the vessel is connected with an exhaust or compression apparatus when the pressure indicated either rises above or falls below a certain value. Diagrams of the apparatus are given in the paper. N. L.

1399. *Minerals and Pseudomorphs from Malfidano (Sardinia).* **F. Millosevich.** (Accad. Lincei, Atti, 9. pp. 153–159, March 4, 1900.)—Crystals of the following minerals from Malfidano mines are described: Cerussite, anglesite, gypsum, cerussite pseudomorphous after anglesite, cerussite after phosgenite, smithsonite after calcite, and smithsonite after anglesite.
T. H. P.

1400. *Irreversible Processes.* **S. H. Burbury.** (Phil. Mag. 49. pp. 475–486, May, 1900.)—This paper discusses mathematically Boltzmann's H theorem. The conclusion is drawn that the H theorem does not prove that, in the test system of colliding elastic spheres, the diminution of H is irreversible in the same sense as loss of kinetic energy by friction. The process is, however, held to have a certain physical significance. E. H. B.

1401. *Fundamental Theories of Pressure.* **L. Boltzmann.** (Ann. d. Physik, 1. 4. pp. 673–677, April, 1900.)—Hertzian mechanics always proceed from a definite number of material particles, however large, and never from a real *continuum.* By indefinitely increasing the number of particles, making their density continuously variable from point to point, and allowing each point to retain its density permanently, a well-defined and detailed mental picture of the whole world of physical phenomena may be obtained. The author is, however, not convinced of the utility of such a detailed conception. It involves the introduction of some arbitrary hypotheses which may at any time have to be abandoned. From a philosophical point of view, the conception of an incompressible fluid or a rigid impenetrable body has no advantage over that of atoms acting at a distance. The former is derived in an equally rough manner from the approximate behaviour of liquid and solid bodies, as the latter from that of the heavenly bodies. E. E. F.

1402. *Propagation of a Solitary Wave.* **R. F. Gwyther.** (Manchester Lit. & Phil. Soc., Mem. 44. 9. pp. 1–12, 1900.)—The writer refers to the researches of Russell, Rayleigh, and others on the solitary wave, and points out that the complete solution is difficult owing to the difficulty of satisfying the surface conditions over the whole wave. It is necessary to approximate. The general method adopted is to find a solution with close approximation in some parts of the wave, generally the outskirts, and then to find the degree of approximation attained in other parts. Two terms of approximation corresponding to the two first terms of a series are worked out mathematically, and the results compared with Russell's experiments. Stokes has suggested that the motion is not one capable of being reduced to steady motion, but that a gradual reduction of the altitude of the wave is a necessary part of the

phenomenon. The method of the present paper, the author says, is not adapted for the investigation of this question. S. H. B.

1403. *Wave Velocity and Group Velocity.* **H. Lamb.** (Manchester Lit. & Phil. Soc., Mem. 44. 6. pp. 1-5, 1900.)—It was observed by S. Russell that a group of waves has less velocity of propagation than the individual waves composing it. Rayleigh has shown that where V, the velocity of the individual wave (Russell's wave velocity), is a function of λ the wave-length, then U, the velocity of the group, is given by—

$$U = V - \lambda \frac{dV}{d\lambda}$$

Hence Lamb deduces the geometrical representation: If λ be abscissa and V ordinate, and we draw the curve $V = f(\lambda)$, U is the intercept of the tangent on the axis of V. He then mentions three special cases, according as (1) gravity alone acts and V varies as $\sqrt{\lambda}$; or (2) capillarity alone, in which case V varies as $\frac{1}{\sqrt{\lambda}}$; or (3) both gravity and capillarity, in which case V varies as $\sqrt{\frac{\lambda}{a} + \frac{a}{\lambda}}$. This latter case is discussed. The writer also refers to the cases of 4) waves of flexure travelling along an elastic rod where V varies as $\frac{1}{\lambda}$, and (5) waves on a tense string, every point of which is urged towards its equilibrium position with a force varying as the displacement, in which V varies as $\sqrt{a^2 + \lambda^2}$. S. H. B.

1404. *Life of Matter.* **C. E. Guillaume.** (Archives des Sciences, 9. pp. 133-146, Feb., 1900.)—The author specifies certain physical processes which have close analogies in physiology, and may be regarded, in fact, as constituting an elementary form of life in the biological sense. Among the processes so specified are those of fatigue and those of adaptation to impressed forces. An instance of the latter is the hardening of a metal at the constriction which appears at the point of impending rupture. If, before rupture actually takes place, the bar is turned to a uniform diameter, it will, if exposed again to a breaking stress, invariably break at a point different from that at which rupture was about to take place before. An even more striking case of protective modification is presented by the grey iodide or chloride of silver in the Becquerel process of colour photography. The silver salt assumes the colour of the light which impinges upon it, and thus enables itself to reflect it. If it did not do that it would have to absorb the radiation, and the energy so absorbed would have the effect of reducing the silver salt.

E. E. F.

1405. *Spectrum of the Corona.* **J. N. Lockyer.** (Roy. Soc., Proc. 66. pp. 189-192, April 4, 1900.)—This paper contains the results of measurements of the wave-lengths of rings due to the corona, obtained from five of the eight plates exposed during the eclipse of January, 1898, in India. The rings found on the photographs were divided into three groups, determined by the position-angles in which they showed greatest brightness. The typical examples of each class are, λ 5,303·7 (green), λ 3,987 (violet), λ 4,359·5 (blue). A drawing is given showing the different appearance of each of these ring following which are three tables giving the details of all other coronal lines under their respective types. In all forty-five lines are assigned wave-length

The question as to the presence of carbon in the corona is still unsettled, but there is a possible trace of the fluting at λ 4,736·18. Minute examination of the form of the green corona ring shows that it is more intimately associated with the inner corona, in fact it appears to have no distinct connection with the outlying streamers. The outer corona gives no indications of bright line spectra. C. P. B.

1406. *Circulation in the Atmosphere.* **V. Bjerknes.** (Phys. Zeitschr. I. pp. 215–217, Feb. 10, 1900. Report read before the 71 Naturforscherversammlung in Munich. Full paper in Meteorolog. Zeitschr., March & April, 1900, pp. 97–106, 145–156.)—The paper is based upon a generalisation of Kelvin's circulation of a curve. If a series of material points of a continuous fluid with definite velocities form a closed curve, the integral of the tangential components of the velocities is called the circulation of the curve. It is a constant quantity provided the density of the fluid be simply a function of the pressure. In order to discuss the general case without restriction as to density, the author imagines the fluid to be divided by surfaces of equal pressure. These isobaric surfaces will be closed belts all round the earth or cut the earth, but cannot cut one another. The same applies to isosteric surfaces of equal specific volume, which will be at different levels owing to local differences of temperature. The intersections between the two systems of surfaces will be tubes, which he designates solenoids, and any closed curve will enclose a definite number of solenoids. From a consideration of the normals to the two kinds of surfaces, the gradients and the mobilities, the author derives rules concerning rising air currents in warm spots and descending currents in cold spots, showing that the wind must blow from the cold to the warm district on the surface of the earth, and from the warm to the cold districts at higher levels. In this way he accounts for trade winds, land and sea winds, valley and mountain currents, monsoons, and even cyclones. Friction, rotation, and water vapour are not taken into consideration. H. B.

1407. *Thermodynamics of the Atmosphere.* **W. v. Bezold.** (Preuss. Akad. Wiss. Berlin, S. ber. 20. pp. 356–372, April 19, 1900.)—The author discusses the decrease in the atmospheric temperature with the altitude as would result simply from vertical air currents, and makes use of the term "potential temperature," *i.e.*, the temperature which a body assumes when reduced to normal pressure, adiabatically or pseudo-adiabatically. Expansion of air, saturated with humidity, can be truly adiabatic only when any condensed water remains suspended in that bulk of air; otherwise the change is pseudo-adiabatic. The difference hardly affects the formulæ. But it must be considered when an ascending current changes into a descending current, because it is then of importance, whether or not the moisture, condensed during the rising, is still carried by the air. Adiabatic changes of humid air do not alter the potential temperature, pseudo-adiabatic changes raise it; the potential temperature increases with the altitude. At high altitudes the rate of decrease in the temperature should approach 1° C. per 100 m. The Berlin balloon observations confirm this conclusion: between 7,000 and 8,000 m, $-\Delta t = 0{\cdot}72^\circ$; between 8,000 and 9,000 m., $-\Delta t = 0{\cdot}90^\circ$. In the medium and lower strata, convection currents and radiation from the soil complicate the conditions and make temperature reversals much more common than was formerly assumed. But pseudo-adiabatic expansion, with subsequent condensation, raises the temperature of the medium strata of chief cloud forma-

tion, so that, eliminating cases of reversal observations, the temperature gradient is only 0·54° between 1,000 and 4,000 m., whilst it is 0·61° between 0 and 1,000 m., and 0·64° between 4,000 and 5,000 m. Radiation of heat from the earth is the chief source of the atmospheric heat, but the losses by radiation overcome the gain so far as the relative temperature in the vertical is concerned. The second part of the paper deals with compound convection currents, cases when moist air, ascending at one spot, descends to another spot, which receives the benefit of the heat absorbed for evaporation at the starting-point. Such convection currents make the zones bordering upon the belt of calms warmer, and their effect upon the climates of various latitudes is discussed with regard, not to equal differences of latitude, as is often done, but to zones of equal area. H. B.

1408. *Propagation of Earthquake Motion.* **R. D. Oldham.** (Roy. Soc., Phil. Trans. 194. pp. 135–174, March 29, 1900; Roy. Soc., Proc. 66. pp. 2–3, Feb., 1900.)—From the examination of some earthquake observations which are considered specially reliable, the author comes to the general conclusion "that in the complete record of a distant earthquake three distinct types of wave motion can be recognised—(1) condensational; and (2) distortional plane waves, travelling by brachistochronic paths through the earth; and (3) elastic, or gravitational elastic, surface waves, travelling round the surface of the earth. The records are, however, often incomplete by the omission of the first, or the first and second, of these phases; and the widely divergent estimates of the apparent rate of propagation of the preliminary tremors are largely due to this." A. G.

REFERENCES.

1409. *Compensation of Relative Gravitational Results.* **A. Venturi.** (N. Cimento, 11. pp. 33–46, Jan., 1900.)—The paper is a mathematical analysis of the probable errors involved in the use of a Sterneck's apparatus (possessing four pendulums) for the determination of the relative values of the accelerations due to gravity. A. G.

1410. *Stellar Radial Velocities.* **H. C. Vogel.** (Preuss. Akad. Wiss. Berlin, S.ber. 20. pp. 373–390, April 19, 1900.)—This paper consists of a review of the progress made in the spectroscopic determination of stellar velocities in the line of sight during the last ten years. C. P. B.

LIGHT.

1411. *Propagation of Light through Absorptive Media.* **Sagnac.** (Soc. Franç. Phys., Bull. 141. pp. 3–4, Jan. 5, 1900.)—The author shows how his kinematic explanation of the transmission of light through matter [see Abstract No. 48 (1900)] may be applied to the case of anomalous dispersion. Account must be taken of the changes of phase which accompany the reflection of vibrations at absorbing particles which resemble resonators. The case of Hertzian resonators shows that the taking in of energy by emission or by transformation into heat has two principal effects :

(1) To each one of the resonators' own periods θ_0 corresponds a band of absorption more marked in proportion, as the damping of its own vibrations due to the external borrowing of energy is more considerable.

(2) The forced vibrations of the resonant system experience an acceleration of phase when their period θ is less than θ_0, a retardation when θ is superior to θ_0, a change of phase of a quarter of a period when θ has the value θ_0.

Hence there results that on the violet side of the absorption band there is an acceleration of the phase of the vibrations reflected by the surface of the absorbing body, and a diminution of the index of refraction ; on the red side of the absorption band a retardation of phase by reflection occurs, and an increase of the index of refraction.

For $\theta = \theta_0$ the changes of phase introduced by absorption cancel each other sensibly for transmitted vibrations, but the change of phase of a quarter of a period affects the reflection at the absorbing body. This last phenomenon, especially frequent in the case of the metals over the extent of the visible spectrum does not occur in the reflection of Hertzian vibrations at a mirror of dimensions much greater than the wave-length, because the material particles are not resonant, and electric induction comes into play in the surface portion of the mass as a whole, and brings into action the electric conductivity ; on the contrary, for visible luminous vibrations, and for metals such as silver, it seems permissible to neglect the phenomenon of electric induction throughout the extent of the superficial layers. J. J. S.

1412. *Determination of Refractive Index.* **E. Cominotto.** (Rivista Sci.-Industriale, 32. pp. 49–50, March 10, 1900.)—A simple method of determining the refractive index of a liquid is the following : It is enclosed in a spherical glass vessel exposed to solar or other parallel rays. The distance f of the focus from the centre of the sphere is measured, as well as the radius r of the sphere. Then the refractive index of the substance is—

$$n = 2f / (2f - r).$$

The author deduces this simple rule from Gauss's theory of thick lenses, and verifies it experimentally. The method also applies to solids obtainable in the form of spheres. E. E. F.

1413. *Refractive Indices of Solutions. III.* **C. Bender.** (Ann. d. Physik, 2. 1. pp. 186–196, May, 1900. [See Abstracts Nos. 1471 (1899) and 35 (1900).]—This part of the work deals with the refractive index of KCl solutions as dependent upon concentration and temperature. The spectrum lines studied

were the three lines at H. For $\mu = 1$, or 74·58 gr. in 1 litre at 15°, the formula for $H\alpha$ is, between 10° and 40°,

$$H\alpha = 1{\cdot}3422598 - 0{\cdot}00026695\left(\frac{t}{5}\right) - 0{\cdot}000030227\left(\frac{t}{5}\right)^2$$

As regards the dependence of n upon the concentration μ, we have the formula for $H\alpha$,

$$n = (\text{water}) + 0.0096895\,\mu - 0{\cdot}00025820\,\mu^2$$

for 15° to 70°, and $\mu = 0$ to 3.

The molecular refraction of KCl is calculated from the formula—

$$m\mathrm{R} = \frac{\mathrm{Q}r - q\rho}{\mu}$$

where q is the weight of the solvent in grammes, m the molecular weight of the solute (for KCl 74·58), μ the number of gramme-molecules in solution, Q the weight of the unit of volume in grammes, r the "refraction constant" of the solution, ρ that of the solvent, and R that of the solute. This "refraction constant" may be any one of the following:—

$$\frac{n-1}{d},\quad \frac{n^2-1}{d},\quad \frac{n^2-1}{(n^2+1)\,d},\quad \text{or}\quad \frac{n^2-1}{(n^2+2)\,d}.$$

Taking the last of these, the molecular refraction of KCl comes out at about 11·5. It increases at first slightly with the concentration, and then decreases again. The refractive index of solid KCl for $H\alpha$ at 15° C. should be 1·5175, as derived from the values for $\mu = 1$. Similarly, the atomic refraction of potassium is 9·60, and its refractive index 1·2187. E. E. F.

1414. *Obliquely-Crossed Cylindrical Lenses.* **S. P. Thompson.** (Phil. Mag. 49. pp. 316–324, March, 1900.)—This paper consists of an attempt to arrive at easier rules for obliquely-crossed cylindrical lenses. Sometimes ophthalmic surgeons prescribe (for the correction of astigmatism) a lens with two cylindrical curvatures on the respective faces of the lens, not crossed at right angles but at some oblique angle. As such lenses are difficult of manufacture, and as their optical effect can be precisely reproduced by a suitably calculated and more readily ground sphero-cylindrical lens, the optician desires to have simple rules for calculating the equivalent sphero-cylinder. The author discusses this problem, which is that of finding the combination consisting of one thin cylindrical lens and one spherical lens, which will be the optical equivalent of a system made up of two thin cylindrical lenses placed in contact behind one another, with their axes making with each other a certain angle. He finds that two given cylindrical components A and B may be compounded to find their cylindrical resultant C by means of a parallelogram in which, however, the angle between A and B is drawn as double the actual angle between the axes of the two given components. Hence follows a simple graphic construction for obtaining the required solution of the problem, so far as the cylindrical part of the desired equivalent combination is concerned. The author next considers the method of obtaining the corresponding expression for the power D of the spherical part of the equivalent combination, which is found to be—

$$\mathrm{D} = \frac{\mathrm{A} + \mathrm{B} - \mathrm{C}}{2}$$

The results obtained are stated in three working formulæ as follow :--

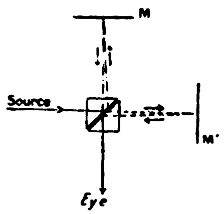
$$C = A^2 + B^2 + 2AB\cos 2\theta \qquad (1)$$

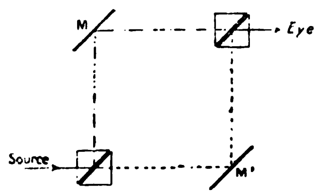
$$\mathrm{Sin}\ 2\phi = \frac{B}{C}\sin 2\theta \qquad (2)$$

$$D = \frac{A + B - C}{2} \qquad (3)$$

Where θ = the angle between the axes, Oa and Ob, of the two given cylindrical lenses having powers A dioptrics and B dioptrics respectively; ϕ = the angle between the axis Oa and any line Oc drawn through O along which are taken the cylindrical components of the two given cylindrical lenses A and B. J. J. S.

1415. *Camera Lucida.* **A. Lafay.** (Comptes Rendus, 130. pp. 1122–1123, April 23, 1900.)—The camera lucida designed by Govi consists of two rectangular prisms forming, when combined, a cube. One of the faces which touch each other is covered by a very fine layer of platinum, gold, or silver,





which is semi-transparent, and, in addition, a layer of Canada balsam is inserted between the two faces. Besides its original application, the author has used this apparatus for refractometric experiments, in a manner which is sufficiently indicated by the annexed diagrams. E. E. F.

1416. *Photometry of Black Bodies.* **H. Wanner.** (Ann. d. Physik, 2. 1. pp. 141–157, May, 1900.)—The author tests the validity of the Wien-Planck radiation formula,

$$J = c_1 \lambda^{-5} e^{-\frac{c_2}{\lambda T}}$$

with the aid of a König spectrum photometer, between the temperatures of 990° (absolute) and 1,570°, and the wave-lengths 0·6678 μ and 0·4861 μ. The sources of radiation were an electrically glowing platinum strip in the middle of a reflecting hollow sphere, a large porcelain vessel, and a small platinum crucible. The above formula was confirmed throughout the region specified. The logarithm of the photometric intensity was found to be a linear function of the reciprocal of the absolute temperature, and the constant c_2 was found to have the value 14509. The formula places at our disposal a simple and accurate method of determining the highest temperatures, as well as the "apparent temperatures" of the stars. Experiments with zirconia show that its brightest radiation is of the "black" type. [See also Abstract No. 1188 (1899).] E. E. F.

1417. *Kirchhoff's Law and Electrically Glowing Gases.* **E. Pringsheim.** (Ann. d. Physik, 2. 1. pp. 199–200, May, 1900.)—M. Cantor recently [see Abstract No. 1012 (1900)] described an experiment which went to show that the glowing

gases in a vacuum tube do not perceptibly absorb a beam from an arc light sent twice through the tube, although they have a considerable intensity of emission. As against the conclusions drawn by Cantor, the author points out that for two reasons he need not have expected a positive result. The discharge is an intermittent one, and hence the gas is only for a small fraction of the time in a condition in which Kirchhoff's law would apply. And further, the spectrum radiated and the spectrum to be absorbed are of a very different nature, and a very narrow slit would have to be used. Besides, Liveing and Dewar have actually observed the reversal of the C and F lines, which shows that there must be absorption, though probably the absorption is much smaller than might be expected from Kirchhoff's law. E. E. F.

1418. *Luminous Motion and Fourier's Formulæ.* **Gouy.** (Comptes Rendus, 130. pp. 560–562, Feb. 26, 1900.)—The author has formerly treated the case of constant luminous motions—that is, those in which the phenomena are independent of the time, which is the ordinary case. When rays from a luminous source pass through a luminous system, experiment shows that the intensity of illumination at any point whatever is sensibly constant—that is, any variations which may occur are so rapid as to be insensible to the observer, who can only appreciate the mean intensity during an interval including necessarily a great number of vibrations. The author in his former paper established this mean intensity, making use of Fourier's formulæ. Carvallo, in remarking upon the method of calculation employed, threw doubt upon the application of Fourier's theorem to such a case, and in the present paper the author insists that by the use of Fourier's method general results are obtained which always apply, and cases realisable in nature are not left on one side. He considers that Carvallo has given no good mathematical reasons for the rejection of the large part of physical theory which would follow on the adoption of his opinion. J. J. S.

1419. *Electrostatic Images on Photographic Plates.* **W. Schaffers.** (Comptes Rendus, 130. pp. 897–898, April 2, 1900.)—Images are produced on a sensitive plate by an induction coil, using two needles as poles; the positive needle touches the plate, the negative is about half a millimetre off the plate. A sheet of metal below the plate facilitates the action. The image produced consists of a number of small black lines resembling arrows directed from the positive to the negative pole. The image is formed without development, and is insoluble in a hyposulphite of soda fixing bath. The author finds that the image is due at first to the fusion of the silver bromide and of the medium, and after prolonged action to the reduction of the bromide. Substituting iodide of gold for bromide of silver, the image consists of continuous brown lines connected by numerous ramifications. G. H. B.

1420. *Didymium and Erbium Absorption Spectra.* **Liveing.** (Cambridge Phil. Soc., Proc. 10. pp. 213–214, Jan., 1900.)—The dilution of solutions of didymium and erbium salts produces no increase in the intensity of the absorptions when the thickness of the absorbent is proportional to the dilution. The effect of acidifying the solutions is to make the absorptions generally more diffuse, but not sensibly to weaken them, and to extend the general absorptions at the most refrangible end. A rise of temperature from about 20° C. to 97° or 98° also makes the bands more diffuse, but does not increase their intensity. It seems to the author improbable that the metallic atoms should "maintain such independence in combination as to have the

same absorptions in such different compounds as chloride, nitrate, and sulphate, and it is more probable that the common absorptions are due to common products of decomposition. These might be the metallic ions, but the facts that neither dilution nor rise of temperature increases the intensity, and that acidifying does not weaken the intensity of the common absorptions, are against that supposition. Ionisation implies an electrification of the ions, which again implies a communication of energy to the field, which may probably depend on the circumstances of the encounter when the molecule of salt is broken up, and so some molecules may be broken up without being charged; while there is no reason to suppose that the absorption by a molecule would be altered by its being charged with electricity. The absorptions which are intensified by concentration and also by heat must be ascribed to the condition of the molecules during encounters, which will be more frequent in more concentrated as well as in hotter solutions. The expansion of certain bands with increased concentration by the nitrate must be ascribed to encounters of molecules derived from the metal with those derived from the acid, which are much more massive than the molecules of water and also than those derived from the chloride. During such encounters the absorbent molecules will be, as it were, loaded by the influence of the other molecules. This view seems confirmed by the influence which other solvents and other acids have on the absorptions. Didymium chloride in alcohol gives the same bands as the aqueous solution, but generally more diffuse and more or less shifted a little towards the red. The same solution acidified with hydrochloric acid exaggerates greatly these modifications, almost washing out the more refrangible bands and breaking up the very strong band in the yellow into several separate bands. Glycerol as solvent gives modifications similar to, but more strongly marked than those of alcohol. The acetate in acetic acid and the maleate in water gives similar but much less marked modifications. The tartrate and the citrate in ammoniacal solution also give similar modifications. The borate in solid glass of borax also gives bands which are unmistakably modifications of those produced by the aqueous solution. All these modifications seem to be of the same character, though of greater intensity, than the differences between the bands given by nitrate and chloride, and may be attributed to the influence of the comparatively complicated influences of the various molecules during the times of encounter. In such cases as the acid alcoholic solutions there will certainly be at least four chemical compounds mixed in the solvent, which may well produce a complicated modification of the bands without destroying their identity."

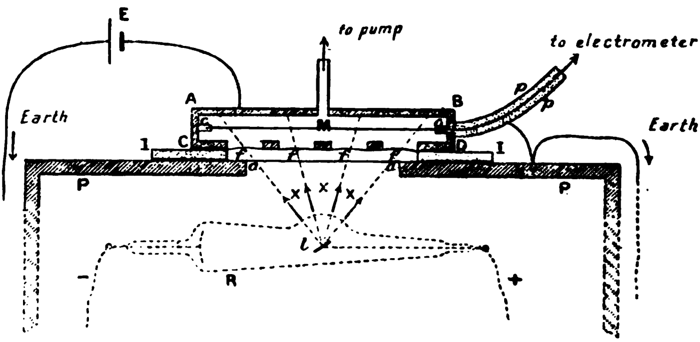
E. E. F.

1421. *Spectra of Canal and Kathode Rays.* **A. Wüllner.** (Phys. Zeitschr. 1. p. 132; Discussion, pp. 133–134, 1899. Report read before the Naturforscherversammlung in Munich.)—The author takes special care to separate the light proceeding from kathode rays, canal rays, and positive column. He finds that, whatever the material of the electrodes, the spectra observed simply depend upon the gas in the tube, but they bear a different character according to the rays from which they proceed. Thus the oxygen spectrum shows the bands in the case of the kathode rays and the lines in the case of the canal rays.

In the discussion following the reading of the paper, **Goldstein** and **Ebert** corroborated the predominant influence of the gas. The former expressed an opinion that the canal rays have a decomposing action, which accounts for the appearance of the hydrogen lines alone in the spectrum of ethylene and other hydro-carbons.

E. E. F.

1422. *Electric Charge of Secondary Röntgen Rays.* **P. Curie** and **G. Sagnac.** (Comptes Rendus, 130. pp. 1013-1016, April 9, 1900.)—The authors have tested whether Röntgen rays, and the secondary rays which proceed from bodies they impinge upon, carry with them an electric charge. They found that the charge conveyed by Röntgen rays, if any, is inappreciable, but that the secondary rays, like kathode and Becquerel rays, convey a negative electric charge. The apparatus used to prove this is shown in the diagram, where M is a thin sheet of metal connected with an electrometer, and enclosed in a box A B C D of a different metal N, having windows f, f towards the Röntgen tube R covered with thin sheets of the metal N. To prevent absorption of the secondary rays by air, the box A B C D is exhausted. Under the influence of the X-rays the combination of the metals M and N acts like an electric battery whose E.M.F. produces a deflection of the electrometer. By Curie's method of opposing a piezo-electric E.M.F. derived from a piece of



quartz it is possible to measure the electric current necessary to maintain the electrometer at zero. If, under these circumstances, the apparatus is exhausted, the equilibrium of the electrometer is maintained at first by the same compensating E.M.F. until the pressure falls to about 1 mm. The compensating E.M.F. then rapidly increases, soon surpasses 1 volt, and grows until a Crookes vacuum is approached. A steady current sets in, which becomes constant at a certain high exhaustion. When the metals are lead for N and platinum for M the compensating E.M.F. is about 20 volts, though 1 volt suffices at atmospheric pressure. The authors discard the explanation based upon an increased contact electrification in a vacuum. Both metals emit negative and accumulate positive electricity, but platinum is the more active, and hence it charges itself positively with respect to the aluminium. The emission of negative electricity is in direct proportion to the emission of secondary Röntgen rays. E. E. F.

1423. *Motions Produced by Röntgen Rays.* **L. Graetz.** (Ann. d. Physik, 1. 4. pp. 648-654, April, 1900.)—It is not certain that the rotations produced in vacuum tubes under the action of kathode rays is directly due to the impact of projected particles. The rotations appear at low pressures long before there is any appearance of kathode rays, and they cease at exhaustions at which these rays are still present in full strength. Another argument may be based upon the author's discovery that light bodies made of dielectrics exhibit under suitable conditions rapid rotations when exposed to Röntgen rays. Radiometers do not rotate, but even experience a retarding action, *ly due to* the electrostatic forces developed by the ionisation of the

air. The author introduces small spheres, bells, and vanes mounted on needle-points into an electric field traversed by Röntgen rays. They begin to rotate as soon as the radiation strikes them, and continue to rotate while the rays continue. The direction of rotation depends upon the initial tendency, at least in the case of non-conductors. When a pair of copper vanes are substituted, the direction of rotation changes with the direction of the rays if the axis of rotation is normal to the path of the rays. This is easily explained by the forces acting between the negatively charged wall of the Röntgen tube and the vanes immersed in the ionised gas between the condenser plates. The latter may even be dispensed with, and so the original conditions of Crookes' rotations are approximated to. The rotations are strictly analogous to those described by Quincke in the case of liquids, and are covered by Heydweiller's theory. E. E. F.

1424. *Radiographic Stereometer.* **T. Marie** and **H. Ribaut.** (Comptes Rendus, 130. pp. 748–750, March 12, 1900.)—An improved stereometer is described by means of which the distance of the object studied can be found, not only with regard to a horizontal plane (that of the sensitive plate), but also as regards two vertical planes at right angles to each other. The stereometer consists of the apparatus previously described (March 22, 1897), but mounted in a frame which only permits of displacement in a certain horizontal line. This again is mounted in another frame which only permits of motion in a line normal to the other line, and also horizontal. Knowing the two displacements and the height of the object, as well as the height of the focus tube above the sensitive plate, the position of the object is calculated in Cartesian co-ordinates by simple formulæ. The apparatus is simple in construction and application, and its accuracy is far in excess of medical requirements. E. E. F.

1425. *E. Pabst's Antikathode for Röntgen Tubes.* **F. Kurlbaum.** (Elektrotechn. Zeitschr. 21. p. 287, March 22, 1900.)—This is an antikathode covered electrolytically with platinum black. The coating of platinum black enormously increases the heat-emissivity of the antikathode, thereby enabling it to be subjected to a much greater degree of kathodic bombardment before it becomes red-hot, with the result that the intensity of the Röntgen rays obtainable from it are very largely increased. If the antikathode does happen to get incandescent the platinum black becomes converted into platinum grey, but even platinum grey has four times the heat-emissivity of polished platinum. The object, of course, is the same as that to attain which the water-cooled antikathodes have been introduced, and is much less cumbersome and much easier to construct. R. N. L.

1426. *Radium Rays.* **E. Dorn.** (Comptes Rendus, 130. p. 1126, April 23, 1900.)—The author claims priority over Becquerel in the discovery of the electrostatic deviation of radio-active barium bromide. He also mentions another interesting discovery. Lenard had found that the action of kathode rays upon a fluorescent screen is reduced or increased by the action of an electrostatic field, accordingly as the lines of force have the same direction as the rays or the opposite direction. The same phenomenon is shown by the rays of radio-active barium. E. E. F.

1427. *New Radio-active Substance.* **A. Debierne.** (Comptes Rendus, 130. pp. 906–908, April 2, 1900.)—By treating pitch-blende with the reagents

used for the extraction of metals of the iron group, and more especially of titanium and thorium, the author has succeeded in discovering a new radio-active substance which has the general characteristics of thorium but does not follow that metal through all its reactions. If a barium or bismuth salt is added to a solution of the new substance the salt added may be eliminated by means of ammonia or hydrogen disulphide without thereby eliminating the radio-activity. This proves that the latter is not due to either radium or polonium. The author calls the new substance "actinium." It produces the same phenomena of fluorescence, photographic action, and ionisation as radium and polonium. The author supposes that the new substance is the active principle of thorium radiation. E. E. F.

REFERENCES.

1428. *Spectra of Oscillating Discharges.* **G. A. Hemsalech.** (Journ. de Physique, 8. pp. 652–660, 1899.)—The author has continued the work commenced by Schuster and Hemsalech, and in the present article gives the results of his studies of the spectra of aluminium, bismuth, copper, cadmium, zinc, lead, iron, cobalt, hydrogen, oxygen, and saline solutions. Photographic comparisons of the ordinary and self-induction spark spectra are included in the present article. (See also 1899. Abstracts Nos. 1377 and 1860.) C. P. B.

1429. *Echelon Spectroscope.* **A. A. Michelson.** (Amer. Acad., Proc. 35. pp. 111–119, 1899.)—This appears to be the author's standard communication of his work to the American Society, but is practically identical with previous papers already referred to in Abstracts Nos. 1118 (1898) and 1678 (1899). C. P. B.

1430. *New Interpretation of Michelson's Spectrum Work.* **E. Carvallo.** (Comptes Rendus, 130. pp. 496–499, Feb. 19, 1900.)—This is an application of the theory of damped vibrations to explain the phenomena observed by Michelson with the interferential micrometer, from which he deduced the multiple character of radiations from their visibility curves. C. P. B.

1431. *Magnetic Perturbations of the Spectral Lines.* **T. Preston.** (Roy. Dublin Soc., Trans. 7. pp. 7–22, 1899.)—The substance of this paper has been published in the Phil. Mag. (vol. 47. p. 165, 1899. See also Abstract No. 1000, 1899), but appears here in a complete form. From the work carried out by the author it appears that the observation of the radiating phenomena in the magnetic field is likely to afford a valuable means of inquiry into the so far hidden nature of the events which bring about the radiation from a luminous body, and also to give us, perhaps, some clearer insight into the structure of matter itself.

[For notices of earlier work by the same author on this subject, see Abstracts Nos. 755 and 1032 (1898), and 477 (1900)]. J. J. S.

1432. *Dispersion of Light in the Electromagnetic Theory.* **A. Antonelli.** (N. Cimento, 10. pp. 372–379, 1899.)—A mathematical paper, working out the results of considering molecules, apart from one another in the ether, as minute Hertzian resonators. It does not lend itself to abstracting. A. D.

1433. *Photography by Röntgen Rays.* **T. Guilloz.** (Comptes Rendus, 130. pp. 355–357, Feb. 5, 1900.)—Discussion of difficulties in clinical radiographic work, arising from the production of secondary rays by surrounding objects, including the body of the operator, and by the body of the patient. A. D.

HEAT.

1434. *Law of Atomic Heat.* **S. Meyer.** (Ann. d. Physik, 2. 1. pp. 135–140, May, 1900.)—In comparing the atomic and molecular volumes with the atomic and molecular magnetisms of elements and compounds it has been shown that a contraction of volume attending the formation of compounds leads to an increased magnetic susceptibility, and an expansion leads to a decrease. The author has established a similar relation for atomic and molecular specific heats. According to Richarz a small atomic weight combined with a small atomic volume foreshadows a deviation from Dulong and Petit's law. During combination the masses are added, but the volume may be greater or smaller than the sum of the atomic volumes. In the case of contraction deviations from the additive law of Joule, Kopp, and Neumann are to be expected, a greater dependence upon the temperature coming into play. Also the molecular heat comes out smaller than the sum of the atomic heats at the same temperature. In the case of expansion the opposite might occur. The greater dependence upon the temperature can hardly be proved as yet, but comparisons at the same temperature go to confirm the suppositions stated. Thus the following substances show a strong concentration and also a distinct decrease in the molecular heat: Sb_2S_3, FeS_2, MnS, $PbBr_2$, KBr. On the other hand, Cu_2I_2, and AgI show an expansion and an increase of molecular heat. SnS_2, which contracts, shows an irregular behaviour. Assuming the atomic heat of oxygen to be 4·9, the author shows that the same rules hold good for a large number of oxides, some of which contract, while others expand on formation. The only exceptions so far are B_2O_3 and Bi_2O_3. E. E. F.

1435. *Liquid Mixtures of Constant Boiling-point.* **G. Ryland.** (Chem. News, 81. pp. 15–16, Jan. 12; 42–43, Jan. 26; and 50–51, Feb. 2, 1900. From the American Chemical Journal, vol. 22, Nov., 1899.)—The author examined eighty binary mixtures of liquids mutually soluble in all proportions, and two mixtures of liquids whose mutual solubilities are limited. He found that forty-five of the former give distillates which boil at a constant temperature, the ratio of the components in the distillate then being nearly that of the products of the vapour densities and vapour pressures of the pure liquids at that temperature; that both of the latter mixtures form distillates with the like property so long as there are two layers of liquids in the distilling flask; that these distillates are, however, not true chemical compounds. A historical sketch of the work previously done in this regard is given, and the author's arrangement for distillation under reduced pressure is described, as well as, in fuller detail, his work on mixtures of methyl alcohol and of ethyl alcohol with benzene. R. E. B.

1436. *Cooling of Saturated Steam by Free Expansion.* **J. H. Grindley.** (Roy. Soc., Phil. Trans. 194. pp. 1-36, Feb. 19, 1900.)—In a paper on the Dryness of Saturated Steam and the Condition of Steam Gas, read before the Manchester Literary and Philosophical Society on November 3, 1896, Osborne Reynolds describes a method of experimenting in which it is sought to determine whether by sufficient withdrawing of saturated steam at a known

initial pressure and temperature the steam could be finally brought into the condition of steam gas. The method is as follows: If saturated steam be wire-drawn through a small orifice from one chamber in which the pressure is kept constant to another in which the pressure can be adjusted to have any lower value, the steam in the second chamber will become superheated, and at first the temperature will fall, but if the pressure in the second chamber can be reduced so far that the amount of superheat contained by the steam is sufficient to bring it to the condition of a perfect gas the temperature will then be unaffected by further reduction of pressure. Whether this "perfect gas" condition can be reached, is the primary object of the present research to decide.

The author gives a short theory, an account of preliminary experiments, intended to settle the best form of apparatus to be used, and describes the nature of the orifice and arrangement of the apparatus used for the final experiments. The pressure of the steam before entering the orifice was observed on a Bourdon gauge, the pressure of the wire-drawn steam by a mercury gauge. The temperature of the wire-drawn steam was determined by inserting a thermo-junction of iron and copper into the steam channel, the wires passing out of the channel through small glands. A similar thermo-junction in circuit with the first is placed in an oil bath, the temperature of which could be adjusted to any required degree. In this bath a thermometer was fixed, and the equality of temperature between the junction in the oil and the junction in the steam was shown by a galvanometer. The method of experimenting and the corrections for the pressure gauges and thermometers are described.

The first experiments showed that the chief source of error was the radiation of heat from the channel containing the wire-drawn steam; this was subsequently remedied by the use of a steam jacket. The corrected results of twenty-eight experiments made with saturated steam at temperatures varying from 240° to 380° F. are given in a table. From the results of the experiments a diagram is plotted with pressures for abscissæ and temperatures as ordinates. On this diagram the initial condition of the steam in any experiment is shown by a point on the saturation curve. A mean curve is drawn through all the points obtained by using steam in a given initial condition. The relative accuracy of the experiments is clearly shown by the fact that the greatest distance of any point representing a p-t relation in any experiment from the main curve through the points is not greater than the expected error of experiment. The first point of importance brought out by the experiments is that the steam never became a perfect gas. The curve representing the p-t relation in steam wire-drawn from a definite initial condition coincides for a short distance with the saturation curve, the length of the coincident portions varying with the initial temperature of the steam. The curvature of the lower ends of the curve of free expansion is very small and regular, even to pressures of 2·5 lbs. per square inch absolute. Hence superheated steam is never even approximately a perfect gas. The value of the specific heat of superheated steam at constant pressure is easily obtained from the curves of cooling. The experiments show a very large variation of its value with the temperature, from 0·49 at 260° mean temperature to 0·65 at 305°, but its value is practically independent of the pressure. The results from this research are compared with the values of the specific heat at constant pressure as deduced from Hirn's experiments; the variation of K_p, as shown by Hirn's experiments, is much greater than that deduced from the [pres]ent experiments. [See also Abstract No. 1274 (1900).] A. S.

1437. *Specific Heat of Gases.* **E. Meyer.** (Phys. Zeitschr. 1. pp. 146–147, 1899. Report read before the Naturforscherversammlung in Munich.)—The ratio of the indicated work done in the cycle of a certain gas engine to the theoretical maximum was found to be 0·870 or 0·653, according as in the calculation of the latter the specific heats of the gases were taken to alter with the temperature according to Mallard and Le Chatelier's law or to be constant. The losses of work due to delayed ignition and to premature outflow can, however, be directly estimated from the indicator card, and on the assumption of the former figure leave too small a proportion of the loss as that due to conduction, &c.; calculation, too, on either assumption of the proportion of loss during the expansion by reason both of cooling and of imperfect combustion gives results that are incompatible with the final state of the gases as determined by chemical analysis, so that the dependence of the specific heat on pressure, as found by Lussana, seems to be real.

R. E. B.

1438. *Law of Velocity-Distribution in a Gas.* **N. D. C. Hodges.** (Phys. Rev. 10. p. 258, April, 1900.)—It is assumed that the molecules in an enclosed space form a conservative system to which the principle of least action applies; that in moving from one given point to another a given molecule will, if the time is large enough, come into contact with as many molecules as there are in the space, and that it will, if the space is large enough, pass through all possible velocities and through each velocity in proportion to the frequency of that velocity among the molecules. Maxwell's law is then easily deduced by taking an expression of the form $AN\int_0^\infty c^2\phi(c)dc$ to represent the least action. [But this expression does not follow without even further assumptions than the above.] R. E. B.

1439. *Characteristic Equation of a Fluid.* **Moulin.** (Soc. Franç. Phys., Bull. 148. pp. 9–10, May 4, 1900.)—The author has verified to a great extent his characteristic equation for any fluid, which is as follows:—

$$pw_1 = \frac{RT}{v} - \frac{b_1 w}{v^{\frac{4}{3}}} + \frac{\frac{R_1}{w_3}T}{v^{\frac{5}{3}}}$$

where p, v, T and R have the usual meaning, b_1 and R_1 are absolute constants independent of the substance, and w and w_1 are, for each substance functions of the temperature related to the same functions at the critical point by the equations—

$$\frac{w_c}{w} = 1 + \gamma\left(1 - \frac{T}{T_c}\right) \text{ and } \frac{w_1}{w_{1c}} = 1 + \gamma'\left(1 - \frac{T}{T_c}\right)$$

Finally, γ and γ' are constants characteristic of each gas. By an application of the theorem of zero area, the author calculates from the first equation the specific volume of the saturated vapour at each temperature, and the maximum vapour pressure, and finds the results to agree with experimental values obtained in the case of benzene, benzene fluoride, carbon chloride, ether, acetic acid, methyl alcohol, steam, and carbonic acid. There is a slight discrepancy in the case of carbon bisulphide. E. E. F.

1440. *Change of Density on Evaporation.* **Mathias.** (Soc. Franç. Phys., Bull. 148. p. 7, May 4, 1900.)—Away from the critical temperature, the ratio s of the heat of internal vaporisation to the change of density is a function

which clearly decreases with the temperature. In the neighbourhood of the critical temperature the ratio appears to be constant, as has been proved by experiments with sulphurous acid. The author calculates the ratio from the results of Amagat, and finds that carbonic acid yields numbers which are almost rigorously constant between 0° and 15°, while between 15° and 31·35 they diminish very rapidly by about 20 per cent. Calculations based upon Young's experiments on normal hexane also yield a steadily decreasing value of *a*, but without presenting a point of inflection with a horizontal tangent, as in the case of carbonic and sulphurous acids. It appears, therefore, that the law of corresponding states does not apply to the ratio *a*. E. E. F.

1441. *Saturation Curve of Carbonic Acid.* **Mathias.** (Soc. Franç. Phys., Bull. 148. pp. 7–8, May 4, 1900.)—If, according to Amagat, one considers the loci of points, such that there is a constant ratio between the volume of the liquid and the volume of the vapour, while their joint weight remains 1 gramme, these curves have, at the critical point, horizontal tangents, except the locus of points implying an equality between the volumes of liquid and vapour respectively. This curve meets the saturation curve at a finite angle. The author shows that Amagat's locus has a horizontal tangent corresponding to a volume which is two-thirds of the critical volume. Hence the locus is geometrically curvilinear, but it is very little distant from the tangent at the critical point, which explains the result obtained graphically by Amagat.

E. E. F.

1442. *Minimum Volume of Fluids.* **D. Berthelot.** (Comptes Rendus, 130. pp. 713–716, March 12, 1900.)—The author employs Cailletet and Mathias' law of the linear diameter to calculate the volume of a liquid at absolute zero. The density of the saturated vapour is neglected in comparison with that of the liquid at the temperature in question. In this way the following molecular volumes (in c.c.) are calculated :—

N_2	O_2	Cl_2	Br_2	CO_2	SO_2	C_2H_4	CCl_4	$SnCl_4$	Ether
25·0	20·8	34·1	38·9	25·5	30	34·3	72·2	87·8	71·7
C_6H_6	C_6H_5F	C_6H_5Cl	C_6H_5Br	C_6H_5I	Pentane	Isopentane	Hexane	Heptane	
66·3	70·6	78·5	82·2	89·2	80·5	81·3	93·5	106·1	

It is stated that the deviations hitherto observed from the law of corresponding states disappear if one reckons volume from a zero equal to the co-volume as calculated above, and temperature from a special zero of temperature for each substance. F. G. D.

1443. *Characteristic Data of Gases and Vapours.* **R. Mollier.** (Phys. Zeitschr. 1. pp. 149–150, 1899. Report read before the Naturforscherversammlung in Munich.)—The author calls attention to the difference of 8 per cent. existing between Regnault's numbers for the heat of evaporation of water, and those given by Battelli and by van der Waals' equation ; the theoretical work of a steam engine is hence only known within about 8 per cent., whilst the real work as given by the indicator is not subject to such a large error. Similar errors are introduced by considering the passage of liquid to vapour as homogeneous, and by our ignorance of the exact behaviour of superheated steam. The same is the case with cooling machines using ammonia, carbonic acid, or sulphurous acid. With gas and petroleum engines differences of 30 per cent. are obtained in the efficiencies given by considering the specific heat of the combustion products, first, as constant up to 1,600°, and secondly as increasing considerably. T. H.

1444. *Critical Temperature of Mixture.* **N. J. van der Lee.** (Phys. Zeitschr. 1. pp. 14–15, 1899.)—Measured quantities of phenol and water were put into a Cailletet tube, and stirred to an opaque emulsion. By raising the temperature the opacity was just made to disappear. It could be made to reappear by raising the pressure, since the temperature of mixture increases with the pressure. The increase is, however, only slight, not exceeding 0·6 degrees for an increase of pressure of 180 atmospheres. On representing the results by means of van der Waals' isothermal surfaces, it appears that the co-nodal lines of the longitudinal fold and the transverse fold touch each other in a point which is also the folding point of the longitudinal fold.

E. E. F.

1445. *Critical Points.* **R. v. Hirsch.** (Ann. d. Physik, 1. 4. pp. 655–663, April, 1900.)—The phenomena observed at the critical points of pure substances and mixtures have given rise to a number of theories at variance with the simple theory of van der Waals and Andrews, notably those of de Heen, Galitzine, and Battelli. The author's experiments with pure ether, and with mixtures of ether and borneol, show that the apparent anomalies may be explained by the influence of gravitation and a retardation in attaining a state of equilibrium, without leaving the ground covered by the simple theory of van der Waals.

E. E. F.

1446. *Entropy and Temperature of Radiant Heat.* **M. Planck.** (Ann. d. Physik, 1. 4. pp. 719–737, April, 1900.)—The author endeavours to find an expression for the entropy of radiant heat which is in agreement with all the data of thermodynamics, and of the electromagnetic theory of light. He is led to the conclusion that Wien's law of the distribution of energy in the spectrum is a necessary consequence of the principle of maximum entropy as applied to electromagnetic radiation. The flaws recently discovered in Wien's law in the regions of large wave-lengths, led the author to a direct calculation of the entropy of radiation which confirms the expression previously found. He also arrives at a numerical value of the temperature of a monochromatic radiation emitted by a small surface and refracted by a system of centric surfaces. The temperature of the radiation is completely defined without reference to that of the body which emits it, or to the losses suffered on the way. It is more rational to speak of the temperature of a monochromatic beam of sunlight than of the temperature of the sun, especially as the distribution of temperature in the solar spectrum differs from that of a black body.

E. E. F.

1447. *Vapour-Pressures.* **R. Gahl.** (Zeitschr. Phys. Chem. 33. pp. 178–214, April 17, 1900.)—In order to measure very small vapour-pressures the author passes a measured volume of air, or, preferably, of the mixed gases resulting from the electrolysis of water, over the substance giving off vapour and then through the purest water procurable, the electrolytic conductivity of which is determined both before and after the experiment. The increase of the conductivity is a measure of the mass of vapour absorbed and consequently of its pressure, the gaseous laws being in this case applicable. By this method partial pressures of less than $\frac{1}{1000}$ mm. of mercury have been measured, and for lower pressures the experiment need only be prolonged: it is not, however, without difficulty, and the author's precautions are therefore given in detail.

The differential equation $n_1 d \log p_1 + n_2 d \log p_2 = 0$, as representing the rela-

tions between the partial pressures of a solvent and solute (n denoting number of molecules and p partial pressure) and Helmholtz's formula (in integrated form) for the relation between free energy and heat of transformation are then discussed, and are found to lead to results which agree well with the author's experiments on aqueous solutions of HCl: the pressures of these solutions are applied to measure the dissociation-pressures of the haloid salts of organic bases: an equation analogous to the above is found to hold between the pressures of NH_3 and HCl in a saturated solution of NH_4Cl, whereby the phenomena accompanying the distillation of such solutions are explained: and the partial pressures of the hydrates of H_2SO_4 and the progressive dissociation of crystalline salts with attached water, which are subject to similar relations, are also discussed. R. E. B.

1448. *Thermodynamic Theory of Muscular Cooling.* **Broca.** (Soc. Franç. Phys., Bull. 143. p. 3, Feb. 2, 1900.)—During asphyxia a tetanised muscle cools, and at the same time changes into the condition of *rigor mortis*, whereas under ordinary circumstances a muscle in action becomes heated. The author points out the thermodynamic explanation of this, in the fact that the contraction is associated with a reaction in which energy is absorbed, and compares the whole process to that of a Clark cell which encloses a vessel in which the current supplied by the cell may be employed to produce electrolysis. R. A. L.

1449. *On the Size at which Heat Movements are Manifested in Matter.* **G. F. FitzGerald.** (Nature, 61. pp. 612–614, April 26, 1900.)—In the molecular theory of heat it is assumed that the motions of very small portions of matter are the motions on which the phenomena of temperature depend. Also, according to the author, they are very irregular motions, taking place within regions too small for direct observation.

But in addition to these motions or vibrations of matter there are, as the author teaches, also motions of ether of an irregular kind, which have an amount of energy capable of estimation. And the size at which these motions are developed is comparable with the wave-length of the ether disturbances. This wave-length is perhaps a thousand times greater than molecular dimensions. For each temperature there is in ether a particular wave-length round which the vibrations are grouped.

He refers to the analogy of sound. A large body may, as regards sound waves, vibrate in unison with a small one, and so be excited by the vibration of the latter, and *vice versâ*. So it may be that the ether vibrations, which, as we are told, accompany the molecular motions on which heat depends, may give rise to electromagnetic vibrations in bodies of size comparable with the ether waves, and therefore far greater than molecular sizes. He discusses what effect such vibrations, if they exist, may be expected to have, and the possibility of their being detected. With regard to the energy of these vibrations he points out that if the energy of the fundamental vibration of a particle corresponds to its one degree of freedom according to the Boltzmann law of equal partition of energy, it will be too small to account for any observable phenomenon. But as the theory of equal partition of energy fails, according to the author, in other cases, we may be justified in expecting that the energy in question may be greater than that assigned to it by Boltzmann's law.

S. H. B.

SOUND.

1450. *Synthesis of Vowel Sounds.* **Marage.** (Comptes Rendus, 130. pp. 746–747, March 12, 1900.)—The author reproduces the various vowel sounds by means of a siren whose lower disc has a single aperture, while the upper movable disc has apertures arranged in various groups. The vowel sound *ah* is produced by closing every fourth aperture, so as to obtain groups of three separated by an interval. The pitch at which the vowel is sung is given by the number of groups per second, the vowel itself by the total number of vibrations per second. To produce the French vowel sounds *é*, *eu*, and *o*, the apertures of the movable disc must be in sets of two, separated by a closed aperture. Transition from one vowel sound to another is made by altering the width of the fixed aperture, which is widest for *o* and narrowest for *é*. For the French sounds *i*, *u*, and *ou* the apertures must all remain open as usual. To pass from one vowel to another, the width of the fixed aperture, the pressure of air, and the resonance must be altered. The vowel sounds may also be reproduced synthetically by sounding a note, and tuning a resonator to unison with the second or the third harmonic. As a practical application, the author proposes to modify the sirens used on board ship so as to give different sounds, from which an international code might be formed. E. E. F.

1451. *Analysis of Vowel Sounds.* **L. Bevier.** (Nature, 61. pp. 467–468, March 15, 1900.)—The analysis of vowel sounds was carried out by the optical enlargement of phonograph records. The author concludes that the vowels as produced by the human organs of speech are composed in the first place of two elements: that due to the vibration of the vocal chords, and that due to the resonance of the mouth and nose cavities. It is not always possible to separate clearly these two elements, but the problem is quite simple for the vowel *a*. The fundamental is due to the vocal chords, and the overtones that are strongly reinforced are due to the mouth and throat resonance. The vowel *a*, at any pitch, and pronounced by any clear voice, contains the following partial tones: (1) The fundamental to which it is sung, with the first two or three overtones. (2) The overtone or overtones whose frequencies of vibration chance to fall between 1,000 and 1,300 vibrations per second. This is the main characteristic of *a*, which serves to identify it to the ear, and remains remarkably constant, no matter what the fundamental may be. (3) The overtone and overtones whose frequencies of vibration chance to fall between 575 and 800 per second for men's voices, with a maximum at about 675; or between 675 and 900 with a maximum at about 800, for the voices of women and children. This is presumably the resonance of mouth and throat cavities resounding as one vessel, and is not as constant as the main resonance described above. The other vowels are not as yet analysed. E. E. F.

ELECTRICITY.

THEORY AND ELECTROSTATICS.

1452. *Thermo-electricity and Thermo-conduction.* **O. Wiedeburg.** (Ann. d. Physik, 1. 4. pp. 758–789, April, 1900.)—The author modifies his previous representation of irreversible processes so as to make it applicable to a physically non-homogeneous body, such as a metal which in consequence of local differences of temperature and potential is traversed by currents of heat and electricity. At the same time the theory is amplified, so as to include not only conduction properly so called, but also Kohlrausch's "transportation" (*Mitführung*) of one current by another, such as that of a current of entropy by an electric current. With regard to this transportation the author formulates a quantitative reciprocity involving the equality of the two transportation capacities, and shows that this assumption serves the same purpose as is usually fulfilled by the second law of thermodynamics. On this foundation the electric resistance and the coefficient of the Thomson effect come out as proportional to the absolute temperature, as actually observed. It also appears that the so-called pure thermal conduction cannot be regarded as purely thermal, since thermal changes necessarily involve changes of cohesion. Thermal conductivity thus becomes a more complex quantity, and this explains the difficulty in discovering simple relations between the two conductivities. E. E. F.

1453. *Magneto-electric Forces.* **C. Raveau.** (Soc. Franç. Phys., Bull. 145. pp. 2–3, 1900; Discussion, 146. pp. 1–2, 1900; also Journ. de Physique, 9. pp. 150–153, March, 1900.)—With reference to unipolar induction the author points out that all experiments on closed circuits are equally well explained on the supposition that a magnet revolving about its axis drags the magnetic lines of force along with it, as on the supposition that it does not. If it be admitted that the lines of force follow the motion of the magnet, no deductions from that supposition can be experimentally verified, as a magnet which would be strictly symmetrical about its axis cannot be practically realised. Even if it could, Maxwell's theory would seem to indicate that the magnetic field could be slightly changed, and an electrostatic field would be produced.

In discussing the above paper, **Crémieu** remarks that if the existence of electric convection currents is admitted, a linear current can theoretically be increased in strength by imparting to the conductor a velocity along its length. Similarly, the magnetic field due to a solenoid should be increased by making the solenoid revolve about its axis in the direction of flow of the current traversing it. This reasoning cannot be directly applied to a permanent magnet, as the analogy is not certain to hold good.

A. Blondel refers to the experiments of Lecher, which appear to him to confirm Faraday's view and to decide against the attachment of the lines of force to the magnet itself. In the reverse case, the lines of force in the gap between two bar magnets placed end to end would be bent by twirling the magnets in opposite directions. [See also Abstracts Nos. 94 and 850 (1900).]
E. E. F.

1454. *Thermo-magnetic Phenomena.* **G. Moreau.** (Comptes Rendus, 130. pp. 562–565, Feb. 26, 1900.)—A mathematical paper in which the author seeks to show that his interpretation of the thermo-magnetic effect of Nernst

differs from that of Voigt, and that it is confirmed by experiment. He concludes that under the action of a magnetic field only the thermo-electric forces relative to the Thomson effect undergo the Hall effect. J. J. S.

DISCHARGE AND OSCILLATIONS.

1455. *Dissociation Theory of the Electric Arc.* **C. D. Child.** (Phys. Rev. 10. pp. 151–160, March, 1900.)—By photographing a narrow longitudinal section of an alternate-current arc on a long moving film, Brown showed that the arc is formed by the coalescence of two light-fronts, starting from the positive and negative carbons respectively [see 1899, Abstract No. 1720]. The negative light-front starts first, but the positive one moves with the greater velocity. The former circumstance is easily explained, as the negative carbon was positive during the previous half-period, and was therefore the hotter of the two. As regards the difference of velocity, it is difficult to account for it without having recourse to some ionic hypothesis. Such an hypothesis has been framed by the author, who supposes that the negative ions move more slowly than the positive ions. This is the reverse of what happens in the case of dissociation by Röntgen rays. The greater velocity of the positive ions would not only explain the fact observed by Brown, but also the greater fall of potential at the positive pole. Manometric experiments show that the pressure near the positive carbon is greater than that near the negative carbon. The author explains this on the ground that owing to the smaller speed of the negative ions their number between the poles at any given time must exceed the number of the positive ions. Hence they exert a greater attraction upon the positive pole than do the positive ions upon the negative pole. E. E. F.

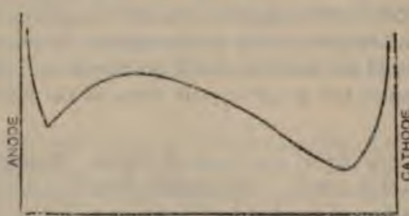
1456. *Magneto-Optic Effect on Vacuum Tubes.* **Dongier.** (Soc. Franç. Phys., Bull. 147. pp. 5–6, 1900.)—The author describes a new arrangement for showing the polarisation of the light of a vacuum discharge in a direction at right angles to the magnetic field which envelopes it. As regards the explanation proposed by Egoroff and Georgiewsky [see 1900, Abstract No. 1289], ascribing the phenomenon to the magnetic displacement of the luminous thread and consequent changes in the reflection and refraction due to the glass walls, the author remarks that, if that explanation were true, the behaviour of different gases must be identical, whereas hydrogen and nitrogen show characteristic differences, and so do helium and argon. Cotton proposes an explanation based upon the supposed existence of an absorbing gaseous layer which is crowded out when the luminous thread is pressed against the wall. If this is true, the phenomenon must disappear in a magnetic field which is strictly uniform. E. E. F.

1457. *Electrostatic Deflection of Kathode Rays.* **A. Heydweiller.** (Phys. Zeitschr. 1. pp. 15–16, 1899.)—Spherical vacuum tubes of the ordinary Röntgen ray pattern were used, but the polarity of the electrodes was reversed, so that the antikathode, instead of reflecting the kathode rays at right angles, cast a shadow on the wall opposite the original anode. On approaching a rubbed ebonite rod to the tube, a considerable but momentary enlargement of the shadow was observed. A rubbed glass rod produced a corresponding contraction. Under favourable conditions, the dimensions of the shadow could be doubled or halved respectively. A permanent enlargement was produced by putting the antikathode to earth, and this enlargement was perceptible even in the case of strong discharges, whereas the other deflections required very weak currents. If any part of the stem of the antikathode was left

uncovered, the change in the dimensions of its shadow was very much more pronounced than the other changes. A curious point noticed is that the approach of the charged body produces in the first instance a disappearance of the phosphorescence on the wall, succeeded by the temporary appearance of the modified shadow. E. E. F.

1458. *Use of Braun's Kathode Ray Tube.* **L. Kallir.** (Zeitschr. Elektrotechn., Wien. 18. pp. 138–142, March 18, 1900.)—The author has worked out several additional methods of employing the Braun tube for the study of electric and magnetic processes. The fluorescent screen is fixed, and the curves are not drawn out by a lateral motion. The circles or ellipses obtained on the screen are photographed, and used for the evaluation of the energy of a current in watts, and for the quantitative determination of hysteresis in iron. In the case of the latter, the kathode beam is exposed to deflection by two fields at right angles to each other, one due to the magnetising current, and the other to the magnetised body itself. The combination of the two deflections thus yields directly the ordinary hysteresis curves. E. E. F.

1459. *Electric Conductivity of Gases.* **J. Stark.** (Ann. d. Physik, 2. 1. pp. 62–71, May, 1900.—In a gaseous discharge, the speed of the negative ions is in general greater than that of the positive ions. This leads to an accumula-



tion of ions at the anode at the expense of the kathode, and to an increase of conductivity near the anode. This increase is marked by the constant production of new ions at the kathode, by the activity of the kathode rays in lowering the resistance of the gas, and by heat effects. The production of undiffused ions leads to a large increase of resistance at both the electrodes. Neglecting the heat effects, which cannot be at present precisely determined, the author gives the annexed diagram as a typical representation of the specific resistances at various points between the anode and kathode. He verifies it by sending a transverse current through auxiliary electrodes. E. E. F.

1460. *Electric Oscillations in a Free Wire.* **M. Abraham.** (Ann. d. Physik, 2. 1. pp. 32–61, May, 1900.)—The experimental results of Sarasin and Birkeland obtained in 1893 with respect to the electrodynamic occurrences in the field of a wire having a free end are of practical interest now that wireless telegraphy is carried on by such wires. The complete reduction of the phenomena to Maxwell's theory is not possible with the present means of analysis. The author therefore supposes the wire to have the shape of a very elongated paraboloid of revolution. The field surrounding the wire is to change periodically, in such a manner that the lines of force are always normal to the surface. He obtains a convergent series, in the solution of which he pays special attention to the distribution of current and charge along the conductor, and to the displacements of energy in the field. E. E. F.

1461. *Electromagnetic Dispersion of Ice.* **C. Gutton.** (Comptes Rendus, 130. pp. 1119-1121, April 23, 1900.)—By means of his method used for comparing the rates of propagation of electric waves through bitumen with and without wires, the author has determined the dielectric constant and electromagnetic dispersion of ice. The refractive index was found to be 1·76, which would give a dielectric constant of 3·1. The ice was perfectly limpid and dry, and was examined at a temperature a little below zero. It did not perceptibly absorb the electric waves. The value found for the dielectric constant is much higher than that obtained by Blondlot by a different method, and the author therefore suspected that ice would show considerable dispersion for different wave-lengths. The original method not being available for great wave-lengths, he used that devised by Blondlot, in which the wave-length proper to the same resonator is measured first in air and then in the medium under investigation. The refractive indices thus obtained cover wave-lengths ranging from 14 to 2,000 cm. For the smallest wave-length the refractive index is 1·76, as already stated. This becomes 1·73 for a wave-length of 25 cm., and so it goes on decreasing with increasing wave-lengths until it reaches 1·50 at a wave-length of 2,088 cm. This gives a dielectric constant of 2·25, which is not far from Blondlot's value of 2·0 found in still greater wave-lengths. Within the region investigated the dispersion of ice is normal. E. E. F.

1462. *Coherer Action.* **J. Härdén.** (Elektrotechn. Zeitschr. 21. pp. 272-273, April 5, 1900.)—The author desired to examine a coherer while cohering under the microscope. For this purpose he constructed a coherer capable of coming into the field of the microscope and consisting of two fine wires adjusted by micrometer sirens. By a special and very ingenious contrivance the wires were so adjusted that a galvanometer, connected in series with them to a cell, just failed to indicate. When exposed to electric radiation sparks were seen to jump from one wire to the other. On reversing the direction of the current in the sender the direction of the sparks in the receiver was also reversed. Not until the wires were brought with their ends only 0·005 mm. apart did the galvanometer indicate a current when the sparks passed. When steel wires were observed under similar conditions and approached to 0·006 mm. from each other, while sparking under the action of the electric wires, a dark bridge sprang across between them and then the galvanometer indicated. Little particles of metal could be observed passing from the one wire to the other previously to the formation of the bridge. Shaking destroyed the bridge and caused the galvanometer needle to return to zero. R. N. L.

1463. *Hertz Oscillator.* **R. Swyngedauw.** (Comptes Rendus, 130. pp. 708-711, March 12, 1900.)—According to Poincaré and Bjerknes, the vibrations of a Hertz oscillator are similar to those of a damped pendulum in which the intervals between consecutive zeros of intensity are equal, and most resonance experiments confirm this. But the author is of opinion that the question is not quite settled and that the oscillator may produce successively a series of complex oscillations for which the intervals between two successive zeros are unequal. One set of experiments for the purpose of investigating this point is described. The discussion of them is not complete. D. E. J.

1464. *Coherer Phenomena.* **F. Campanile** and **G. di Ciommo.** (Elect. Rev. N.Y. 36. p. 333, April 4, 1900. Translation in abstract of an article in L'Elettricistà.)—The authors prove (1) that the behaviour of a mercury

globule coherer subject to the action of extra current potentials and electric waves is analogous to that of the particles in an ordinary filings coherer under the same actions; (2) that a coherer becomes conducting along certain lines and not in the entirety of its mass.

The experiments were conducted in the following manner: Upon a glass plate were fastened with Canada balsam strips of glass in such manner as to make a long, narrow rectangular cell. At the extremities of this were attached two fine copper wires, amalgamated on the ends, and in the little cell was placed vaseline oil and a small quantity of mercury which was stirred up into globules with a metallic wire. This arrangement was put in circuit with a battery of accumulators, A (fig. 1), a resistance R and a coil B. One of the two small wires *f* is connected with one point of the circuit as shown and the other left disconnected. On breaking the circuit at E, the mercury globules reunite in a fine stream. The arrangement shown in fig. 2 consists of a single cell connected in circuit with a galvanometer G, a key, and the coherer. With the arrangement as shown, the coherer introduces an enormous resistance into the circuit and the galvanometer needle does not deviate. On closing the key T the needle, of course, deviates fully, but remains in the position indicating a short-circuit when the key is opened. If, instead of the single cell, a battery of ten or twelve accumulators is used, on opening the switch T the spherical globules can be seen to unite and spread themselves out into a continuous stream.

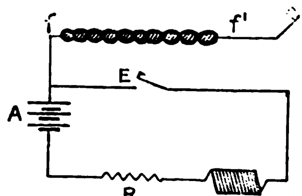


FIG. 1.

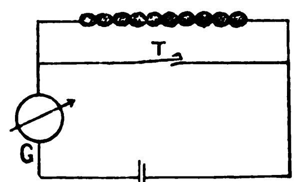


FIG 2

By using a Righi oscillator worked by an induction coil and having the mercury coherer in circuit in the usual way with a battery and galvanometer, a single spark was found sufficient to cause cohering action. Under these conditions the drops do not seem to unite as before, but the galvanometer shows a diminution of resistance, and when one side of the glass cell is removed it will be found that the end globules have connected themselves with the mercury film on the leading-in wires. A glass tube containing vaseline oil and numerous globules of mercury was found to be entirely analogous to a metallic powder coherer.

In order to show that the conductivity does not augment in the entire mass, a glass tube may be used, about 8 inches long, $\frac{3}{8}$ inch in diameter, filled with brass filings and closed at its two extremities with plugs. It is divided into equal parts along its length by exploring electrodes in the form of small brass wires run through holes in the glass. These are connected to mercury cups. If the coherer becomes conducting by the formation of chains of particles between the two end terminals for example, then, it does not follow that it will be conducting between other terminals unless these chains of particles include the entering wires of the latter. From numerous observations it was concluded by the use of this instrument that chains of conducting particles are actually formed and that the coherer does not become conducting in all its mass; that it may

become conducting as a whole and still remain of high resistance from part to part, and that a coherer can become of low resistance in part without showing any diminution of resistance as a whole. E. E. F.

1465. *Maximum Sensitiveness of Coherers.* **A. Blondel** and **G. Dobkévitch.** (Comptes Rendus, 130. pp. 1123–1126, April 23, 1900.)—The increase in the sensibility of the coherer produced by Tissot by immersing it in a magnetic field is simply due to the increased cohesion of the particles, and is therefore a purely mechanical effect. The same increase of sensitiveness may be obtained by increasing the amount of filings between the electrodes, and thus increasing the mutual pressure of the particles. When the extra quantity of filings is contained in a reservoir connected with the coherer tube, the addition may be brought about by shaking the tube, though, of course, this is not so convenient as increasing the magnetic field, as in Tissot's contrivance. For maximum sensitiveness a coherer should fulfil the following conditions: The E.M.F. of the battery should remain below the critical value; the E.M.F. produced by the impinging waves should exceed the critical value; the current established on coherence should be below a certain value (usually 1 milliampere) if the coherer is not to deteriorate; the current which traverses the tube after a shock should be a very small fraction of the preceding current. With a given height of mast, the sensitiveness is, therefore, increased by reducing the critical E.M.F. This may be done by employing filings which are slow to oxidise, and by putting the tube into circuit with a battery of feeble E.M.F. and a relay of feeble internal resistance. The authors use a battery of 0·5 volts, and a tube with a critical E.M.F. of about 1 volt. The relay has a resistance of 100 to 200 ohms. It is even better to substitute for the battery a potentiometer connected with a battery of accumulators. E. E. F.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1466. *Resistance of Bismuth and Antimony.* **R. Wachsmuth** and **C. Bamberger.** (Phys. Zeitschr. 1. pp. 127–128, 1899.)—In antimony the difference in resistance amounts to 6·75 per 1,000 in zero magnetic field, and 5·79 (minimum) in a field of 8,250 c.g.s. It then increases rapidly, amounting to 1·5 per cent. in a field of 14,500 c.g.s.

With bismuth the resistance increases with the frequency of alternation, the value, with 110 alternations per second, being almost the same as the resistance to steady currents. In magnetic fields up to 16,000 c.g.s. the dependence of resistance on frequency ceases completely. G. E. A.

1467. *Thermoelectric Phenomena.* **W. F. Barrett.** (Phil. Mag. 49. pp. 309–316, March, 1900.)—The author describes the peculiar thermoelectric behaviour of a specimen of nickel steel containing 5 per cent. of manganese when coupled with an iron wire. The cool junction being kept in cold water or in ice, it was found that on heating the other junction continuously the thermo-electric force at first quickly rose; but when a certain temperature much below red heat was reached it remained almost stationary, although the hot junction was finally raised to a bright white heat. Further investigation showed that up to a temperature of 320° C. the E.M.F. of the nickel-steel alloy and iron couple rose rapidly; it then remained absolutely constant until the temperature rose to 500°, and after this only a small chang

occurred up to the highest temperature attainable in the gas furnace employed. The mean E.M.F. between 300° and 1,000° C. was, in round numbers, 4,000 microvolts, and the extreme variations from the mean E.M.F. throughout this range were less than 170 microvolts, or about + and — 4 per cent. of the E.M.F. at 300° C., the cooler junction being kept at 0° C. There is a slight and curious oscillation of the E.M.F. about the mean line between 300° and 1,100° C.; when the curve is plotted it is seen to cut the mean E.M.F. at four points, viz., at 310°, 540°, 810°, and 1,030° C. This singular constancy of E.M.F. through a wide range of temperature appears to occur only when iron is used in conjunction with the alloy. When mild steel is used as the second wire with the nickel manganese alloy the E.M.F. is less and remains constant only between 400° and 600° C., after which it begins to fall and continues falling slowly to the highest temperature reached (over 1,000° C.). The specific electrical resistance of this alloy is very high, being no less than 97·52 microhms per c.c. (at 15° C.). Its variation of resistance with change of temperature is comparatively small, the temperature-coefficient being 0·08 per cent. per degree C. between 0° and 250° C. J. J. S.

1468. *United States Standardising Office.* **F. A. Wolff, jun.** (Elect. World and Engineer, 35. pp. 361–365, March 10, 1900.)—The author describes the work undertaken by the U.S. Office of Standard Weights and Measures to provide accurate standards of electrical units and facilities for standardising electrical instruments.

The paper is devoted mainly to resistance standards. The office has not attempted to construct its own mercury standards, but adopts manganin coils standardised at the Berlin Reichsanstalt. It possesses coils of resistances of from 0·0001 to 100,000 ohms in decades and also of 2 and 5 ohms; these are continually compared one with another, and from time to time new coils are purchased. The method of comparison adopted is the Wheatstone-Kelvin bridge, and is fully described.

The standard of E.M.F. is the Clark cell, of which some forty are set up and compared with one another. They are found to agree in value to within 0·005 per cent. Some cadmium cells have been made, but have not yet been compared with the Clark cells.

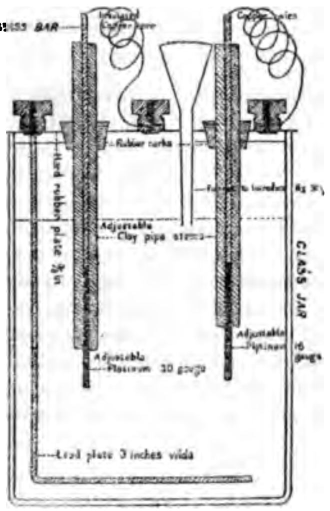
Currents are measured by the fall of potential over known resistances.

G. H. B.

1469. *Wehnelt Interrupter.* **R. Federico and P. Baccei.** (Phys. Zeitschr. 1. pp. 137–138, 1899.)—The current furnished by a Wehnelt interrupter is sent through a coil surrounding a CS_2 tube traversed by a beam of sunlight. The apparatus is furnished with nicols, arranged so that the beam is obscured on closing the circuit and passes through on breaking the circuit. The interruptions may thus be registered on sensitive paper mounted on a cylinder whose speed of revolution is measured by a chronograph. The intensity of the current is indicated by the degree of blackening of the paper. The records so obtained show the current is interrupted for about the sixth part of every period. But the interruption is graduated, and is probably never quite complete. The duration of interruption is more constant than the period. A strong magnetic field shortens the duration of interruption, but interferes with the regularity. By using a bichromate solution instead of sulphuric acid only, the commotion and heating of the interrupter is lessened, and the solution and the electrodes remain clear for a considerably longer time. E. E. F.

1470. *Improved Wehnelt Interrupter.* **W. A. Price.** (Elect. Rev. N.Y. 36. p. 357, April 11, 1900.)—The author describes an adjustable and durable type of the Wehnelt interrupter (see diagram).

The jar consists of a 5-inch by 7-inch gravity battery glass jar with a hard rubber cover. To this is fastened a lead strap 3 inches wide, which passes down one side and across the bottom, having a binding-post on top. Two ¾-inch holes in the cover are fitted with perforated rubber stoppers through which pass ordinary clay pipe-stems about 6 inches in length. Inside each is



placed a piece of brass wire with a platinum tip, about 1 inch long, soldered to it with hard solder.

The interrupter is adapted for long continuous use by using a lead pipe instead of a plate for the kathode and passing a stream of cold water through it to keep the cell cool. A few turns of wire on a bolt used in series to offer a little inductance, very materially assist the working of the interrupter when used on direct current. This is not necessary, however, when used on the alternating current. E. E. F.

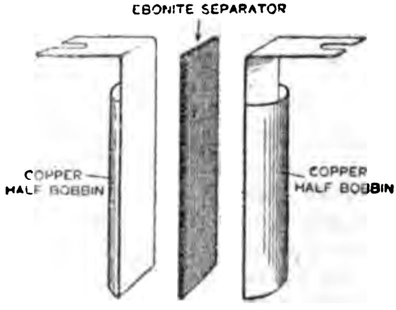
1471. *Liquid Interrupters.* **E. Ruhmer.** (Elektrotechn. Zeitschr. 21. pp. 331–334, April 26, 1900.)—To decide whether the irregularities noted by West (see 1900, Abstract No. 490) in the liquid interrupters of an induction coil are due to the variable resistance of the gap of the secondary or to irregularities in the interrupter itself, the author took mutographic impressions of the spark in the liquid. He found that the irregularity in the succession of sparks amounted to 17 per cent. in the Wehnelt interrupter, and 24 per cent. in Simon's pattern. The latter, on the other hand, showed fewer intermittences of the interruption. The irregularities are indicated to the ear by the impurity of the note emitted. Whenever regular interruptions are required, the mercury-jet interrupter designed by Boas is preferable.
E. E. F.

1472. *Direct-reading Potentiometer.* (Elect. Rev. 46. pp. 761–762, May 4, 1900.)—The subdivided resistance consists of 149 coils connected to studs

arranged in a circle, and a slide wire equal in resistance to one coil. Contact is made with the studs by a slider carried on a circular disc, and the number of the stud under the slider appears below a window in the cover of the apparatus. Contact with the slide wire is made by a radial arm, the position of which is read on a scale divided into one hundred parts. In series with the subdivided resistance are two adjustable resistances which serve to bring the current to the value which makes the potentiometer direct-reading. The potential difference to be measured can be substituted for the standard cell and *vice versâ* by the motion of a double-sliding contact. All the metal connections are encased in ebonite to enable high pressures to be measured with safety. Messrs. Elliott Brothers are the makers. G. H. B.

1473. *Hot-wire Shunt Instruments as Alternating Ammeters.* **E. A. Wagner.** (Amer. Electn. 12. p. 162, April, 1900.)—It is becoming common practice to use a hot-wire instrument with a shunt, care being taken to eliminate self-induction by twisting the leads, the self-induction being negligible in the instrument itself. The reactance of the shunt will vary within wide limits depending upon the frequency, current, and the relative position of other cables carrying current. A convenient method of calibrating is to have a small current transformer arranged to slip over the cable in series with the shunt, and so wound that a 15 or 25-ampere alternating current ammeter can be used. The currents in the transformer will not be affected by the relative position of cables carrying either alternating or direct currents or by the presence of iron. Measurements of alternating currents by means of a shunt is not to be depended upon where the instrument has been calibrated by a direct current. E. K. S.

1474. *J. A. Fleming's Workshop form of Wheatstone Bridge.* (Electrician, 44. pp. 823–824, March 30, 1900.)—The most important features of this instrument are the following : The top and bottom of the box are held in place by turn-button bolts, so that, by turning four buttons, the top of the box can be at once removed, carrying with it the entire bridge mechanism. The coils



are arranged as in a dial-pattern bridge, and are made as follows: Hollow half-cylinders of thin sheet copper are constructed, each having a lug, and two of these half-cylinders are put together with a thin separating piece of ebonite, and bound up with some thin silk tape. The resistance wires of manganin are then cut the proper length, and the two ends of the wire soldered to the two lugs of the copper half-cylinders, the remainder being wound non-inductively on the bobbin and tied in position by thin silk tape.

No paraffin wax is used over the coils. Each set comprises nine coils, interposed between ten brass blocks, which are arranged in a circle around a central brass ring in a kind of ebonite tray fixed on the under side of the teak lid of the box. The plugs are inserted through small holes bored through the teak lid of the box. These holes, when the box is not in use, are closed by means of circular discs of thin ebonite perforated by holes corresponding to the plug-holes in the lid. The discs turn about central pivots, and, by means of a spring, move so that the holes in the shield do not normally coincide with the holes in the box-lid. These shutters can be turned round by a common bar and finger-pin protruding through the lid. The ratio-arms are also arranged dial-fashion, 1, 9, 90, 900. The plugs are of the length of the contact surfaces only so as to prevent shouldering.

C. K. F.

1475. *Balancing Rheostat for Bolometers.* **P. G. Nutting.** (Astrophys. Journ. 11. pp. 44–46, Jan., 1900.)—The error due to varying contact makes the method of Wadsworth (Astrophys. Journ. 5. pp. 268–276) for making fine bridge adjustments, by means of a double contact arrangement for one of the battery terminals unsuitable for use with the differential bolometer in the determination of absorptive indices. The present paper describes a new device in which *both* galvanometer terminals are connected by variable contact to the bridge angles instead of only one, as is usually the case. The bridge junction at one galvanometer terminal is made of rather fine wire, of just sufficient resistance to overcome the inequalities of the bolometer arms. The other bridge junction at the remaining galvanometer terminal is made of large wire of very low resistance, and serves for the delicate final setting. The resistance of this whole wire may be made equal, within about 1 mm. or less, to that at the opposite terminal, but for rapid work it is conveniently of a resistance sufficient to balance the greatest bolometric variations expected. Further details of the arrangements and means adopted to eliminate thermal currents and variations of resistance from temperature changes are given in the paper.

J. J. S.

1476. *Shielded Galvanometers.* **H. du Bois** and **H. Rubens.** (Zeitschr. Instrumentenk. 20. pp. 65–78, March, 1900.)—The authors describe two galvanometers they have constructed, which are protected by steel shields against external magnetic disturbances.

The first is astatic with two pairs of coils, which are enclosed in a cylinder of 5 mm. steel. Outside this is a shorter cylinder of 7·5 mm. steel, which is capable of vertical motion above and below its normal position of symmetry with respect to the coils. The maximum vertical displacement of 18 mm. will compensate for a 15 per cent. difference in the moments of the two sets of magnets. Four controlling magnets are carried on rods fixed to the cover and bottom of the inner cylinder. The weight of the two shields is 5 kilos.

The second galvanometer is non-astatic, with two coils. These are surrounded by a spherical steel shell made in two halves, with a vertical plane of division; its weight is 2·3 kilos. A ring of ebonite fixed vertically on a tripod carries the two coils and the two hemispherical shells, and supports above a vertical rod carrying the controlling magnets. Of these, two are outside the shell, and two between the shell and the coils; the latter, being attached to two concentric tubes passing over the rod and through the shell, can be adjusted from the outside by cross-pieces on the tubes. The galvano-

meter is provided with a carrying case of steel, which is so arranged as to serve as an extra shield when the galvanometer is in use.

The coils, stands, and controlling magnets are interchangeable between the two galvanometers.

The coils are wound in hemispherical shells of 60 mm. inside diameter, which may be of fibre or of steel; in the non-astatic galvanometer steel shells are usually provided to give a better shielding. Each coil, according to its resistance, is divided into from two to four zones wound with wire of varying diameter. The central portion, which is electromagnetically valueless, is filled by a copper plug, acting as a damper. The opposing surfaces of the coils are covered with tinfoil to prevent electrostatic action, and are separated by a distance of 2·5 mm. Coils are provided of three different resistances, viz., 5, 100, and 1,000 ohms. All coils, whether in fibre or steel shells, are interchangeable, and their electrical connections are made by sliding them in place on the galvanometers.

The suspended magnet systems are made in two weights, 300 mg. and 60 mg. for the astatic, and about half these weights for the non-astatic galvanometer. The magnets are made of glass-hard tungsten steel, artificially aged; in the lighter suspension each set consists of five pairs of magnets arranged in a vertical rectangle 4 x 2·5 mm. The two magnets of each pair are curved away from each other so as to diminish their mutual demagnetising action. The precautions to be adopted in magnetising the magnets, and in hanging and astaticising the system, are discussed at length.

The shields are made of cast steel of very high permeability ($\mu = 240$ approximately in a field of 0·015 c.g.s. unit), and small coercive force of not more than 1 c.g.s. unit. They are very carefully annealed, and afterwards kept from contact with any magnet. In the galvanometers the controlling magnets are so arranged as to avoid accidental contact with the shields in taking these off and on.

The "Protective ratios" of the three shields of the non-astatic galvanometer are as follows: The coil shields, 13·3; the spherical shield, 16·6; the cylindrical carrying case, 10·9; the coil and spherical shields together, 120; the three shields together, 900. The measurements were made in a field of 0·015 c.g.s. unit.

For the intercomparison of the sensitiveness of different galvanometers the authors recommend that results be reduced to correspond with a galvanometer of resistance 1 ohm, period 1 second, and scale distance 1,000 scale divisions; in this they agree with Ayrton, Mather, and Sumpner, and Lummer and Kurlbaum. Formulæ are given for this reduction. The current-sensitiveness is then the deflection for 1 microampere, and the ballistic-sensitiveness that for 1 microcoulomb. In the case of the non-astatic galvanometer these sensitivenesses are respectively 80 and 50 for the heavy magnet system, and 800 and 500 for the light one. In the case of the astatic they are 160 and 100, and 1,000 and 630 respectively.

The authors criticise Ayrton and Mather's maximum value of $B = 5{,}000$ for galvanometer magnets, assumed in their formula for the maximum sensitiveness of galvanometers. They find a maximum coercive force in tungsten-steel galvanometer magnets of 60 c.g.s. units, and, taking a minimum demagnetising factor of 0·5, they arrive at a maximum residual value of $B = 1{,}500$. Measurements of their magnet systems show values of from 500 to 1,000, *i.e.*, from $\frac{1}{10}$ to $\frac{1}{5}$ of the value assumed by Ayrton and *Mather*.

G. H. B.

1477. *Magnetometer.* **Cotton.** (Soc. Franç. Phys., Bull. 148. pp. 10–11, May 4, 1900.)—The new instrument described by the author gives in a convenient manner the strength in c.g.s. units of a magnetic field whose lines are approximately horizontal. The strength of field is deduced from the force which the field exerts upon a linear conductor carrying a current of known strength. The conductor is attached to one arm of a balance, and the force exerted upon it is balanced against a weight. The conductor is a wire wrapped round the edge of a kind of paddle, so that the length upon which the force is exerted can be accurately determined, and that length is the only effective portion of the current. The form of the paddle is such that limited magnetic fields, such as that between the poles of an electromagnet, can be measured. To obtain absolute values it is only necessary to know the current traversing the wire in absolute measure. E. E. F.

ALTERNATING CURRENTS AND MAGNETISM.

1478. *Electrolytic Current Records.* **P. Grützner.** (Ann. d. Physik, 1. 4. pp. 738–757, April, 1900.)—Lichtenberg figures have been used by Koenig for obtaining some very pretty current curves, and these curves may be vastly improved by using Buerker's new Lichtenberg powder. But the method, which might be called the electrostatic method, is only available for strong currents. Moreover, the curves are not traced under the eye of the operator, but require "development" by the powder. These objections cannot be urged against the electrolytic method worked out more particularly by the author, who describes in detail the various applications of the method. He uses filter paper prepared with a potassium iodide paste, which he mounts on a revolving metal cylinder, the two electrodes, consisting of platinum springs, being lightly pressed against the paper. When a continuous current is used the anode traces a brown line, due to the evolution of iodine, while the kathode leaves no trace. When an alternating current is substituted the two electrodes make alternate traces. The frequency may be as high as 400 per second without interfering with the clearness of the traces. The only disturbing factor is a short continuance of the production of iodine after the electrode has ceased to be the anode. The intensity of the current is approximately indicated by the amount of iodine evolved, *i.e.*, by the intensity of the line. The author reproduces some beautiful records obtained in this manner. Not only are continuous and sinusoidal alternate currents shown, but also more complicated current curves are represented, as well as the "extra-currents" of induction coils. The minimum E.M.F. required is about 1 volt.

E. E. F.

1479. *Production of Asymmetrical Alternating Currents by means of Electrolytic Polarisation.* **W. L. Hildburgh.** (Elect. World and Engineer, 35. pp. 549–552, April 14, and 585–587, April 21, 1900.)—These two articles are condensations from the author's thesis for doctorate in Columbia University; they are to appear in full in the School of Mines Quarterly, July and October, 1900. The two-cell rectifier was the first form of asymmetrical conductor, worked by the production of counter E.M.F.'s. As ordinarily constructed it consisted of a Leclanché in series with a decomposition cell containing acidulated water between platinum electrodes. It was concluded that the E.M.F. of a Leclanché was too low for the passive E.M.F. On passing a direct current through such a combination so that it aids the E.M.F. of the active cell, a current will flow *just as if the* ohmic resistance only of the cells

was present. If the impressed E.M.F. be opposed to the active E.M.F., and less than the sum of active and passive E.M.F.'s, equal to twice the passive E.M.F., no continuous current will flow; when the impressed E.M.F. is great enough to cause a flow of current, the effective E.M.F. is equal to the difference between the impressed and twice the active E.M.F. Since in the opposite direction the effective E.M.F. is always equal to the impressed, an alternating E.M.F. will cause more current to flow in one direction than in the opposite, *i.e.*, a rectification of alternating current will be produced.

The author examines the effect, on the current curve, of alterations of the area of plates, the resistance of circuit and frequency. A large number of curves were drawn, and a few are given in the first article. The author arrives at the following conclusions for theoretically perfect two-cell rectifiers: the smaller the plates the higher the efficiency—for infinitely small plates the efficiency is one; the higher the total resistance the lower the efficiency; for a particular rectifier there is a maximum value of efficiency for each frequency when the external resistance is zero; the higher the frequency the lower the efficiency—the efficiency reaching a maximum only when the frequency is zero; the efficiency referred to is what the author calls "asymmetric efficiency," and he defines this as the ratio of total to useful unidirectional current in an asymmetric conductor.

In the second article the author deals mainly with single-cell rectifiers. As an electrolyte dilute sulphuric acid seems most suitable, with hydrogen, copper, silver, lead, mercury, &c., as soluble electrodes; the results of experiments with these are given in some detail, and it is stated that the substitution of nitric acid for sulphuric acid did not greatly affect the results.

W. G. R.

1480. *Tracing Alternating Current Curves.* **F. Townsend.** (Amer. Inst. Elect. Engin., Trans. 17. pp. 75–83, Jan.; Discussion, pp. 160–169, March, 1900.)—The essential part of the apparatus required for this method is a Weston voltmeter in series with a special contact-maker; the latter consists of a disc, the perimeter of which, in a bipolar alternator, is divided into two sections; one section is conducting, and since the disc is mounted on the shaft of the machine or on that of a synchronous motor, the current can flow in the circuit of the contact-maker only during one-half of a period. During the active half-period, however, i is proportional to E the electromotive force; i will therefore be an interrupted current having the form of the E.M.F. curve, and the position of the interruption will depend on the position of the movable contact brush. The deflection of the voltmeter will be proportional to the number of impulses per sec., each impulse being proportional to the time integral of the current during the interval $t_2 - t$. Therefore—

$$\theta = \mathrm{K}\int_{t_1}^{t_2} i \,.\, dt = \mathrm{K}_1\int_{t_1}^{t_2} \mathrm{E} \,.\, dt = \mathrm{K}_2\int_{t_1}^{t_2} \frac{d\mathrm{B}}{dt} \,.\, dt = \mathrm{K}_2\,[\mathrm{B}]_{t_1}^{t_2} = \mathrm{K}_3\mathrm{B}.$$

Hence if readings are taken with different positions of the contact brush the curve of induction will be obtained.

To determine a curve of E.M.F. the alternating source of E.M.F. is sent through a small transformer; the author shows in the same way as above that $\theta = \mathrm{KE}$. The curve of induction should differ less from the sinusoidal form than the curve of E.M.F. owing to the relative amplitudes of the higher harmonics, and this fact is brought out in the curves given. The experimental curve of induction was found to coincide with the curve constructed by the laborious method of integration from the E.M.F. curve; the method

described in the paper is the only one to-day which gives the induction curve directly. As a test of accuracy the curve of a complex harmonic E.M.F., determined by the author's method, was compared with the same curve obtained by the usual zero method, in which a telephone receiver is employed as indicator ; a satisfactory agreement was found.

Discussion (pp. 160–169, March, 1900). **S. Sheldon** thought that in order that the instrument may give the induction curve directly the two halves of the cycle of alternation must be perfectly symmetrical. **F. Townsend** remarked that in all practical machines, and almost all alternating current machines, the positive half of the wave is the same as the negative half. **C. P. Steinmetz** explained that the present method differed from previous methods by very favourable features. Broadly speaking, the principle was: To get instantaneous readings of a quantity ; we derive from this quantity another which is a differential of the former, and take integral readings, *i.e.*, average values of the latter quantity. The difficulties incidental to instantaneous readings are thus got rid of, and we are independent of the width of contact, of the impossibility of getting a point-contact of no duration, and of the difficulties of the arc following the contact brush. He did not think the determination of the induction curve by the instrument was important, but the same method can be applied wherever instantaneous values of a quantity are required, and differential values of this quantity are obtainable. **M. I. Pupin** did not think Sheldon's objection very serious, and thought Townsend had enlarged the errors likely to occur. He then introduced the problem which had evolved the present method, viz., the problem of determining "the dynamical hysteresis loop." He explained the importance of this at some length, and the use therein of Townsend's method. **Steinmetz** remarked that Bedell had attempted this method of getting the dielectric hysteresis loop of the condenser, but was not successful. W. G. R.

1481. *Magneto-electric Rotations.* **G. Jaumann.** (Ann. d. Physik, 2. 1. pp. 96–101, May, 1900. From the Akad. Wiss. Wien. S. ber. 108, iiA, Dec., 1899.)—Under the name of "a rotating magnetic flag," the author describes an ingenious apparatus for demonstrating the existence of a magnetic whirl in the interior of a conductor carrying a current. The conductor in question is a beaker filled with mercury, and the indicator is a small magnet attached with one end at right angles to a glass rod running along the axis of the beaker and mounted on pivots. Thus the "magnetic flag" is capable of rotation in a plane at right action to the direction of the current. The beaker is inserted in a tight-fitting copper vessel, which furnishes the return circuit and abolishes the external field due to the current. The bottom of the beaker is perforated to admit an electrode, which plunges into the mercury. To ensure that only the magnetic whirl inside the mercury influences the motion of the flag, the earth's magnetic field is compensated by suitable permanent magnets, and the glass rod, or flagstaff, is weighted so as to insure neutral equilibrium even out of the vertical. When the current is turned on the flag rotates with uniform velocity, the north-seeking pole following the lines of force. The considerable work spent in overcoming the resistance and viscosity of the mercury is taken out of the current, and shows itself in a counter E.M.F. impressed upon the circuit. This counter E.M.F. disappears as soon as the mercury has acquired the angular velocity of the flag. It reappears, but with the opposite sign, when the flag is artificially stopped, until the mercury itself has come to rest again. The flag rotates whether it is lacquered or left in the bare metallic state. E. E. F.

1482. *Magnetic Tests of Iron.* **H. Armagnat.** (Ind. Elect. 9. pp. 153–159, April 25, 1900.)—A description and criticism of the various methods used. In discussing Hopkinson's divided bar method, it is pointed out that errors may arise from neglecting the reluctance of the block, in which the induction is usually very low, and the permeability consequently large. A correction curve can be obtained by using a bar, for which the relation between B and H has been found beforehand. A method due to Ewing is referred to, in which the bar to be tested is cut in two and the pieces are placed side by side, each within a magnetising coil, the bars being then magnetically connected on either side of the coils by two massive iron clamps. Two measurements are made for each value of B, with different distances between the clamps. Two equations are thus obtained, each containing the reluctance of the clamps and contacts, from which this reluctance can be eliminated. Homogeneity of the bars is assumed.

The author considers that the class of instrument most suitable for commercial use is that in which B is measured by the movement of a coil placed in a narrow air-gap and carrying a current. To this class belong the instruments of Kœpsel and Kennelly, and of Siemens and Halske.

With regard to hysteresis loss, this is not appreciably influenced by the frequency of the cyclic magnetisation, provided the iron is sufficiently laminated. A 10 per cent. accuracy in testing is sufficient, in view of want of homogeneity in the specimens and alteration with time. The curious fact, discovered by Fleming, is referred to, that in a straight bar, placed in a solenoid more than 10 diameters long, there is a point where the induction B_0 is such that the actual loss in the bar is the same as it would be if the bar were magnetised uniformly with the induction B_0; this point being at a distance from one end of the bar equal to 0·22 of the length. If the solenoid is traversed by an alternating current, and a test coil is placed at the above point on the bar and connected to an electrometer, the value of B corresponding to the actual hysteresis loss is known. The loss in this, as in other cases, can of course be measured by a wattmeter, whose inductance and capacity should be small. For such work the magnetising solenoid should have few turns, so that the lag of the current may be reduced.

Results obtained with Ewing's hysteresis meter are stated to agree well with ballistic tests when the hysteresis loss is large, but not always when the loss is small. W. H. E.

1483. *Magnetic Screening.* **H. du Bois** and **A. P. Wills.** (Ann. d. Physik, 2. 1. pp. 78–83, May, 1900.)—The authors consider the theoretical and practical value of a triple screen or "armour" for galvanometers. They give equations for the "screening ratio" of spherical and cylindrical screens which are very explicit, and agree well with the observations. When the external diameters of the three spherical screens are 2·555, 4·260, and 8·056 cm. respectively, and their thicknesses 0·27, 0·18, and 0·18 cm., the individual screening ratios are 9·8, 8·7, and 2·5 respectively. The aggregate observed screening ratio is 64·6, while the screening ratio calculated from the equations given is 60·2. Some kinds of cast steel have an initial permeability of over 300. Triple screens made of such material have a screening ratio of about 1,000. The permeability of the sample subjected to the experiments above mentioned was only 151. E. E. F.

1484. *Hysteretic Qualities of Iron and Molecular Magnetism.* **S. Sheldon.** (Elect. World & Engineer, 35. pp. 211–212, Feb. 10, 1900.)—The investigations

in this paper were suggested by the magnetisation of a soft iron wire by torsion and by the observation that, though a linear arrangement of strongly magnetised compass needles was stable in all positions when the needles were placed almost in contact, yet by increasing their distance apart the stability disappeared. These facts, and considerations of Ewing's molecular theory led to the supposition that the retentivity and coercivity of magnetic substances, *i.e.*, the two factors of hysteretic quality, might be dependent on the distance between their molecules. When a rod is twisted the molecules are laterally but not longitudinally compressed; and in order to test whether a longitudinal compression would produce magnetism, a rod of soft iron was hammered on its end, but no magnetism was discoverable. In order to experiment on the compass needles the earth's field was neutralised over a small area and the needles placed therein; the magnetising force was provided by the field of a long bar magnet in various positions and the strengths of these fields relatively to each other were determined by the oscillations of a magnet. The compass needles were placed (1) in linear arrangement, (2) in multiple row arrangement. In (1) it was found that the magnetising force required to break up the arrangement decreased as the distance between the pivots of the needles increased. The author draws a curve showing how the relative hysteretic loss decreases as the distance between the needles increases: it does not become zero, however, but approaches a constant value. In (2) the relation between the magnetising force required to break up the arrangement, and the distance between the rows was studied; it was found that in this case the polarity is more easily reversed owing to the influence of the rows on each other; as the distance between the rows is increased the critical magnetising force is increased because the demagnetising influence of the rows on each other is decreased. A curve is given as before, showing the variation of relative hysteretic loss with the distance between the rows.

In concluding, the author questions to what extent we can apply deductions from observations on compass needles to the treatment of iron. The results obtained show that an iron to have a small hysteretic loss should have its molecules separated along the direction of magnetisation and close together in a direction perpendicular to magnetisation. Rhoades' results (Phys. Rev., Aug., 1898) on the hysteretic qualities of strips cut from transformer iron sheets are in accord with these conclusions; owing to method of rolling, these are more dense on the edges than in the middle, and they are, moreover, less dense longitudinally than transversely. Ewing has shown that the increase with time of hysteresis loss is the result of continual baking, and Roget found that continued exposure of a good sample of iron for seven days to 160° C. trebled its hysteresis constant. W. G. R.

1485. *Time Increase of Hysteresis.* **A. H. Ford.** (Amer. Inst. Elect. Engin., Trans. 17. pp. 135–155, March, 1900.)—This increase, which was shown by Mordey and others to be due to heating, has been further examined by the author. A large number of samples of soft iron and steel, as used in the cores of transformers and armatures, were subjected to annealing or quenching at various temperatures up to 850° C., and then tested by a Ewing hysteresis meter. The value found for Steinmetz's constant, η, ranged from 0·00098 to 0·003, and higher in a few cases. (Loss in ergs per c.c. per cycle $= \eta B^{1\cdot 6}$.) The specimens were afterwards kept at a temperature of 60° C. for 29½ days, their hysteresis loss being measured at intervals. The whole change in the loss varied in different specimens from 12 per cent.

decrease to 140 per cent. increase. Neither the absolute value nor the increase in value of the hysteresis loss appeared to depend distinctly on any single impurity or pair of impurities. Nor were the results materially affected by the initial annealing or quenching, though most samples showed less increase after quenching from red heat. The best sample was an open hearth steel, having as impurities :—Si, a trace ; P, 0·027 per cent. ; Mn, 0·30 ; S, 0·05 ; combined C, 0·06. W. H. E.

1486. *Sudden Changes in Magnetising Force.* **E. Gumlich** and **E. Schmidt.** (Elektrotechn. Zeitschr. 21. pp. 233–236, March 22, 1900.)—Tests were made, with the aid of a magnetometer, to find B-H curves of iron with gradual changes in H, and also with a series of sudden changes. In the latter case soft iron is affected in the same way as by mechanical vibration : the height of the cyclic curve is unaltered, while its width may be diminished by as much as 20 per cent., as compared with the curve for gradual changes in H. With hard metal the difference between the curves is inappreciable. W. H. E.

1487. *Unipolar Induction.* **H. Poincaré.** (Écl. Électr. 23. pp. 41–53, April 14, 1900.)—After referring to the experiments of W. de Nikolaïeve (see 1900, Abstract No. 205), the author proceeds to a critical examination of the vexed question as to whether, when a magnet which is a solid of revolution rotates round its axis, it carries its lines of force round with it or not. He establishes the following proposition : in the case of a circuit consisting of a fixed and a movable portion, the product of the current into the algebraic sum of the magnetic fluxes traversing the circles described by the sliding contacts during their rotation, is proportional to the work done by the electromagnetic forces during a complete revolution, and hence to the torque acting on the movable system ; it is further proportional to the induced electromotive force. By the aid of this proposition, all the phenomena of electromagnetic rotations are easily explained, and explained equally well whether we suppose that the lines of force are carried round by the magnet or remain stationary in space. The consideration of closed circuits thus leaves the question unanswered. The author next considers the case of open circuits. He imagines two annular flat discs of metal connected by a wire, with a similar disc of ebonite between them, arranged in a horizontal plane round the upper end of a vertical cylindrical magnet, the end of the magnet being on a level with the median plane of the ebonite disc. If the ebonite disc is rotated while everything else remains fixed, the condenser formed by the two circular discs and the disc of ebonite will become charged. But according to the theory which ascribes the induction of an E.M.F. to the cutting of lines of force by a conductor (and neglects their cutting by the disc of ebonite, regarding the latter as inert, in accordance with the views of the old electricians), no charge should appear, and that whether we suppose that the lines are fixed or move with the magnet. In this case, then, both suppositions lead to an erroneous conclusion. The author concludes by saying that the question as to the rotation or non-rotation of the lines with the magnet cannot be answered because it has no meaning. A. H.

1488. *Subsequent Magnetism.* **D. Mazzotto.** (N. Cimento, 11. pp. 81–112, Feb., 1900. Read before the Società Italiana di Fisica in Como, Sept. 22, 1899.)—The author describes experiments on what he calls "*subsequent* magnetism" (S.M.), a phenomenon called "time lag in the

magnetisation" by Ewing. The greater number of the experiments relate to the variations that the S.M. undergoes when specimens of iron are subjected to long and repeated annealing and tempering. The apparatus consists of a reflecting magnetometer, the iron—or whatever it is—being placed in a coil alongside. The rods used were cylindrical, 60 cm. in length, and varied in diameter from 6 to 8 mm. The readings were made 0·1, 1, 2, 5, and 10 seconds after closing the circuit, and the numbers representing the S.M. are in hundredths of the total magnetism produced in the bars in 5 minutes. The samples, from various sources were as follows: I., II. Swedish iron from Cagliari, diam. 7·9 mm.; III. Swedish iron from Rome, diam. 7·0 mm.; IV. Mild iron from Professor Ascoli, Rome, diam. 6·35 mm.; V. So-called "common" iron from Cagliari, diam. 7·0 mm.; VI. Wire-drawn iron (coppered), unannealed, from Sassari, diam. 6·6 mm.; VII. Swedish iron from Cagliari, diam. 5·8 mm.; VIII. Wire-drawn iron (coppered), unannealed, from Sassari, diam. 6·9 mm.; IX. "Common" iron from Cagliari, diam. 4·8 mm.; X. "Best" iron, old sample from cabinet, diam. 6·6 mm.; XI. Mild iron as above, diam. 2·85 mm.; XII. Wire-drawn iron wire (galvanised), annealed, from Sassari, diam. 5·8 mm.; XIII. Steel, diam. 6·5 mm.; XIV. Nickel, a bundle of 28 wires, each 1 mm. in diameter.

The samples were experimented on in their natural state, as received; then annealed at a bright red heat, and cooled in air and the tests repeated. Some of the results are shown in the following tables:—

Time.	Samples.											
	I.	III.	IV.	V.	VI.	VII.	IX.	X.	XI.	XII.	XIII. Steel.	XIV. Nickel.
0''·0	29·4	13·9	12·7	12·1	5·6	30·6	6·0	—	17·0	—	1·9	0·0
0''·1	10·4	5·8	5·2	5·4	1·5	16·4	3·5	—	15·0	—	1·2	0·0
1''·0	8·1	4·0	4·4	3·1	0·7	12·5	2·8	—	11·6	—	0·8	0·0
2''·0	5·3	—	2·6	2·6	—	9·1	2·6	—	9·2	—	—	0·0
5''·0	2·0	1·4	1·2	1·8	0·5	4·4	2·0	—	5·1	—	0·6	0·0
10''·0	1·0	0·7	0·7	1·4	0·4	2.0	1·3	—	3·2	—	0·4	0·0
1'	0·3	0·4	0·3	0·5	0·0	0·5	1·0	—	1·2	—	0·0	0·0
5'	0·0	0·0	0·0	0·0	0·0	0·0	0·0	—	0·0	—	0·0	0·0
Permeability	49	23	16	21	—	29	10	—	4·4	—	10·5	1·2
0''·0	49·8	36·9	35·4	31·5	31·3	30·1	23·8	21·0	20·0	18·6	3·0	0·9
0''·1	31·5	24·9	21·5	18·1	22·2	17·9	14·8	16·9	16·7	10·9	0·8	0·8
1''·0	24·2	18·5	15·0	13·0	18·3	13·3	10·6	12·4	12·7	7·9	0·7	0·9
2''·0	16·5	—	10·3	8·8	—	9·8	7·9	—	9·0	—	—	—
5''·0	8·4	7·7	4·3	4·9	7·6	4·8	4·5	5·9	4·1	3·4	—	—
10''·0	5·3	4·7	2·0	3·0	4·5	2·3	2·8	3·9	3·0	1·8	0·5	0·1
1'	1·6	1·4	0·5	1·1	1·2	0·6	0·5	1·2	1·0	0·8	0·4	0·0
5'	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0
Permeability	78	54	45	48	—	35	27	—	7·0	—	10·7	—

The author concludes that annealing largely increases the S.M. of metals; that wire-drawing, rolling, or hardening strongly reduces S.M.; that permeability follows very closely the variations of S.M. By reversing the order of the experiments, he finds that S.M. is exactly equal during demagnetisation, for the same interval of time, to that obtained during magnetisation.

The S.M. reaches a maximum value after annealing at a bright red heat, no matter whether the specimen be cooled slowly or rapidly.

The author also finds that the S.M. decreases with decreasing diameters; but that a bundle of wires has the same intensity of S.M. as the separate wires. If a rod has been annealed, and is then tempered by being maintained for a long time (or at repeated intervals) at a fixed temperature lower than that of annealing, its S.M. considerably diminishes, tending towards a minimum whose absolute value is lower as the temperature itself is lower. The effects of tempering on the S.M. at any given temperature may be obtained by stopping the cooling of the hot bar at the required temperature without cooling and reheating. There exists an almost perfect parallelism between the variations of S.M. due to tempering, and magnetic hysteresis. With increasing intensity of the field (which in the above experiments was 0·25 c.g.s. units), the percentage of S.M. decreases rapidly for annealed iron, but increases if the iron has been sufficiently tempered. A. G.

1489. *Change of Volume under Magnetic Force.* **G. Quincke.** (Preuss. Akad. Wiss. Berlin, S.ber. 20. pp. 391–395, April 19, 1900.)—Two large thermometer-like vessels filled with ferric chloride are placed between the poles of a powerful electromagnet, the excitation of which causes a motion of the liquid in the capillary stems of the thermometers. The change of volume is deduced from the displacement of the meniscus, the field strength being measured by a magnetic manometer. With 19 amperes exciting the electromagnet and a field strength of 3,577 c.g.s., an apparent volume change of the order of one in ten million is observed. In other experiments one thermometer has its bulb nearly full of iron chloride, and the stem is filled with water. On setting the separating surface of iron chloride and water at different levels between the pole-pieces, the field being 17,400, it is found that the apparent volume change may be positive or negative according as the separating surface is above or below the region in which the magnetic field is uniform. G. E. A.

1490. *Magnetic Orientation of Uniaxal Crystals.* **V. v. Lang.** (Akad. Wiss. Wien, S.ber. 108. pp. 557–567, 1899.)—Results are given of the examination of a number of crystals with respect to the position of the axis of greatest magnetic induction; if this coincides with the morphological axis the crystal is called +, and if not, —. The letter δ or π signifies that the crystal is dia- or para-magnetic. Tetragonal crystals —. Mercurous chloride, δ —; ammonium copper chloride, $(NH_4)_2CuCl_4 + 2H_2O$, π —; magnesium platinocyanide $(+ 7H_2O)$, δ —; tinstone, π +; rutile, π +; ammonium dihydrogen phosphate, δ —; potassium dihydrogen phosphate, δ —; ammonium dihydrogen arsenate, δ —; potassium dihydrogen arsenate, δ —; calcium copper acetate, $CaCu(C_4H_6O_6)_2 + 8H_2O$, π +; urea, δ —; erythrite, π —. Rhombohedral and Hexagonal crystals —. Nickel silicofluoride, $NiSiF_6 + 6H_2O$, π +; cobalt silicofluoride, π +; potassium cadmium chloride, K_4CdCl_6, δ +; ammonium cadmium chloride, δ +; potassium ferrocyanide with potassium sodium nitrate, $K_4FeCy_6 + 2NaK(NO_3)_2$, δ +; corundum, δ +; beryl, π —; calcium sulphite, $CaS_2O_6 + 4H_2O$, δ +; strontium sulphite, δ +; lead

sulphite, $\partial +$. In magnesium chromate crystals, $MgCrO_4 + 7H_2O$, which are diamagnetic, the magnetic induction is greatest parallel to the long direction of the prisms and least along the axis perpendicular to the cleavage faces. T. H. P

1491. *Crystallisation in the Magnetic Field.* **S. Meyer.** (Akad. Wiss. Wien, S.ber. 108. pp. 513–515, 1899.)—The author finds that when solutions of various salts are allowed to evaporate in a strong magnetic field (10,000 c.g.s. units), the crystals formed are regularly orientated with regard to the lines of force. With a solution containing cobalt and zinc sulphates the mixed crystals obtained consist of long, prismatic needles having their long directions parallel to the magnetic lines. Manganese and cobalt sulphates both form rhomboidal plates the long axes of which point towards the poles. In the case of ferrous ammonium sulphate the long axis is turned perpendicular to the direction of the field; cobalt chloride also gives regularly orientated crystals. As a general rule evaporation of the solutions takes place more quickly in the magnetic field than outside it. With ferrous sulphate, nickel sulphate, potassium ferro- and ferri-cyanides, potassium bichromate, copper sulphate and bismuth nitrate, no such regular arrangement of the crystals is observed. The paper is accompanied by photographs. T. H. P.

1492. *Terrestrial Magnetic Elements of Potsdam.* **M. Eschenhagen.** (Ann. d. Physik, 2. 1. pp. 197–198, May, 1900.)—The means of the hourly values for 1899 are:—

Declination	10° 0·7′ W.
Horizontal Force	0·18818 c.g.s.
Vertical Force	0·43392 c.g.s.
Dip	66° 33·3′ N.
Total Force	0·47297 c.g.s.

The expected increase in magnetic perturbations has taken place.

The magnetic survey of Prussia has so far been confined to the eastern provinces. E. E. F.

1493. *Determination of Direction of Earth's Magnetic Field.* **G. Bongiovanni.** (N. Cimento, 11. pp. 15–32, Jan., 1900. Read before the Società Italiana di Fisica, Sept., 1899.)—A small bar of iron is placed with one pole on a line at right angles to a small compass needle feebly magnetised. In the first place let us imagine that the bar is magnetically elastic, possessing no residual magnetism. When the bar is at right angles to the magnetic field it is free from magnetism, and exercises no action on the compass needle. On rotating the bar in a horizontal plane about the pole already mentioned it becomes magnetised and deflects the needle. The two positions in which no action is exercised on the needle give a line at right angles to the magnetic meridian. Having found the magnetic meridian the bar may be rotated in a vertical plane containing the magnetic meridian. The two positions of the bar in which no action is exerted on the needle give a direction which is at right angles to the earth's magnetic field.

In practice hysteresis complicates matters; but the magnetic meridian can be determined by rotating the bar in a horizontal plane first in one direction and then in the other. The two pairs of positions in which no directive influence is exercised on the needle are symmetrically situated with regard to

the line at right angles to the magnetic meridian. A similar remark applies to the next stage.

An apparatus is described which enables the above-mentioned manipulations to be carried out. An explanation is also given of the way in which the apparatus can be used to obtain the magnetic susceptibility of the bar. A. G.

MEDICAL ELECTRICITY.

1494. *E.M.F and Resistance of the Electric Organ of Malapterurus.* **F. Gotch** and **G. J. Burch.** (Roy. Soc., Proc. 65. pp. 434–445, Jan., 1900.)—The electrical discharges of an excised piece of the electric organ taken from a freshly killed fish were excited artificially by stimuli applied to it through its nerve. The piece experimented upon was 15 mm. in length, and contained approximately 530 discs. The maximum E.M.F. of the discharge was a little more than 25 volts, thus giving 0·048 volt for each disc or component of the piece examined. By calculating the total number of the discs in the entire organ of the fish it is estimated that the E.M.F. of a discharge of the whole is about 200 volts; but as the fish was artificially cooled to 5° for the experiments, it is believed that the maximum discharge at more normal temperatures would be higher than this. The shocks felt by one of the experimenters during the dissection of the fish support his measurements of the E.M.F. The low figure of 17 volts for the whole organ, as given by d'Arsonval, was probably obtained by the employment of an unsuitable method of measurement.

The resistance of the electrical organ when measured across the discs was two or three times as great as the resistance measured in a direction parallel to the disc surfaces. In each case the resistances were independent of the direction of the current between the electrodes.

The measurements of E.M.F. were taken by an electrometer and a moving photographic plate. H. L. J.

1495. *Excitation of the Electric Nerve of the Torpedo by its own Current.* **Mendelssohn.** (Comptes Rendus, 130. pp. 1274–1276, May 7, 1900.)—It is known by the experiments of du Bois-Raymond, Kühne and Hering that any motor nerve can be excited by its own current closed upon itself. In view of the analogy of structure and function which exists between a striated muscle and the electric organ, it appeared a matter of interest to ascertain by experiment whether the electric nerve of the torpedo could be excited by its own current. By a procedure similar to that known to physiologists as Kühne's nerve demarcation current experiment, the transverso-longitudinal current of the electrical nerve was closed upon itself. Experiments upon 32 torpedoes of various sizes proved the following points: (1) There is produced at closure a discharge which can be felt, and which affects the galvanometer and the telephone. A discharge at opening could not be shown owing to the conditions of the experiment. (2) The intensity of the discharge bears a direct ratio to the size and vigour of the animal; in other words, to the length and thickness of the electrical nerve. (3) Under stimulation the "demarcation current" soon gets weak, but a fresh transverse section will restore it. (4) The discharge produced by closing the nerve current does not occur throughout the entire electrical organ, but is limited to that part of the organ near the particular nerve. A series of rapid closures of the nerve current produces a series of discharges, which, however, remain distinct, and do not

run into each other. In other words, a tetanus of the electrical organ is not produced.

From the foregoing facts it is evident that the electric organ of the torpedo can be excited by its own current. This method of excitation must play an important part in the process of excitation which accompanies electrogenesis in electric fishes. It is also evident that a small quantity of energy is sufficient to produce an electrical discharge in the torpedo. A nerve current at 0·015 volts closed upon itself can produce a discharge of the electric organ of from 8 to 15 volts. W. S. H.

1496. *Fibromas and "Galvano-Caustic" Treatment.* **Frédéricq.** (Archives d'Él. Médicale, 8. pp. 198–202, May, 1900.)—The author describes three cases of uterine fibromata and mentions twenty others which he has treated by electrolytic chemical cauterisation with excellent results and without any untoward accident. His conclusions are that intrauterine galvano-cauterisation with the positive pole has an evident hæmostatic action, and clearly explains the disappearance of the hæmorrhages. As to the disappearance of the symptom of pain many factors contribute. The first and chief of these is the cessation of the hæmorrhages, which, by modifying the circulation of the pelvic organs, diminishes the congestion; further, the diminution in the size of the tumour, which sometimes occurs, does away with the symptoms of compression. Lastly, there is the sedative effect on the nervous system of the galvanic current. A symptomatic cure may be obtained without a diminution in the size of the tumour. As a matter of fact, the symptoms in such cases do not bear any direct ratio to the size of the tumour.

W. S. H.

1497. *Experimental Reaction of Degeneration by Means of Injections of Strophanthine.* **J. Cluzet.** (Archives d'El. Médicale, 8. pp. 193–197, May, 1900.) —Strophanthus, as is well known, acts as a muscular poison: a few milligrammes injected into the peritoneal cavity of a frog makes the muscles inexcitable a few minutes after the injection. It seemed to be a matter of interest to ascertain through what intermediate phases the electrical reactions of the muscles pass before complete disappearance.

The experiments were made upon four groups of frogs with doses of strophanthine varying from 1 to 2 milligrammes. To make the electrical examination, the injected frog was fixed in such a manner as to permit free contraction of the gastrocnemius of one side—the contractions being registered by means of a myograph.

Results obtained: In every instance before any manifestation of abnormal electrical reactions, the reactions obtained were identical with those in the normal muscle of man, *i.e.*, the kathodic closure contraction was the first to appear, then anodic closure contraction and anodic opening contraction, lastly kathodic opening contraction.

The four groups were injected with a solution of increasing strength and the following results were obtained:—

Group 1. Weakest injection; electrical reactions continued normal for four hours after injection. Then inversion of the formula appeared, *i.e.*, anodic closure produced contraction sooner than kathodic closure. Two days after the injection electrical reaction normal.

Group 2. Electrical reactions remained normal about four hours, then reversal of the formula. Six hours after injection the muscle was tetanised by the passage of a continuous current. Seven hours after injection opening

contractions no longer obtainable and Faradic excitability much diminished. Eight hours after injection Faradic excitability increased and opening contractions reappear. Inversion of the formula remains. On stimulating the trunk of the nerve the only modification observed was inversion of the formula commencing with the period of galvanic tetanisation of the muscle. Three days after, electrical reactions had returned to normal.

Group 3. Three hours after injection the muscle is tetanised by the passage of continuous current, opening contractions disappear, Faradic excitability much diminished, on excitation of the nerve trunk great diminution of Faradic excitability, inversion of the formula. Eight hours after injection Faradic excitability of the muscles was lost and all excitability in the nerve had disappeared. Thirty hours after injection muscular excitability completely lost.

Group 4. All the frogs of this group died two hours after the injection, after having showed all the successive phases above described. W. S. H.

1498. *Influence of the Anode upon the Conduction of Nerve Impulses in Man.* **S. Leduc.** (Comptes Rendus, 130. pp. 750-752, March 12, 1900.)—The conduction of impulses along a motor nerve trunk is interfered with by the proximity of the anode. The effect is shown in tracings of voluntary muscular contractions taken with an electrode placed over the course of the nerve experimented on. When the electrode is made positive a decrease is registered in the amplitude of the contractions, and this decrease is roughly proportional to the magnitude of the current passing from the electrode to the region of the nerve. The same effect of the anode upon conduction is seen with impulses set up by artificial stimulation of the nerve at points above the position of the anodal electrode. H. L. J.

1499. *Action of Currents of High Frequency and High Potential upon Chronic Pulmonary Tuberculosis.* **E. Doumer.** (Comptes Rendus, 130. pp. 602-605, Feb. 26, 1900.)—The subject has been studied during four years and upon seventeen cases, occurring in both sexes, and the following results have been obtained with considerable uniformity: The night sweats and the evening fever gradually diminish in the second week of the applications; the appetite increases, and the cough decreases during the second month. Occasionally the tubercle bacilli have disappeared from the expectoration, which also becomes diminished in quantity. The stethoscopic evidences of disease in the lungs slowly grow less. The first five cases treated have remained in good condition for fully two years since the termination of the treatment.

The mode of application consists in the brush discharge from a powerful d'Arsonval high-frequency apparatus directed to those regions of the chest and back beneath which the existence of diseased lung is suspected. The treatment lasts from five to twelve minutes at each application, and is given daily or three times a week. H. L. J.

1500. *Finsen's Phototherapy.* **S. D. Benoliel.** (Elect. World and Engineer, 35. pp. 314-315, March 3, 1900.)—The paper describes the details of an apparatus used by G. J. Hopkins, of Brooklyn, for the cure of lupus by electric light after Finsen's method. The light of an 80 ampere arc lamp is concentrated by lenses of quartz arranged in a telescopic tube in which is a water chamber to absorb the heat rays. The light comes to a focus at a distance of 4 inches from the end of the telescope. At this point it impinges upon the diseased part after passing through another arrangement

of a quartz plate and a quartz lens with water circulating between them. This is called the skin lens and is attached to the part by elastic tapes. It exercises compression upon the affected surface, emptying the bloodvessels there and so rendering the tissues more transparent. H. L. J.

REFERENCES.

1501. *Ammeters and Voltmeters.* **H. Armagnat.** (Écl. Électr. 22. pp. 370–379, March 10, 1900.)—An article illustrated by good drawings, dealing with some modern instruments and their latest developments. Among others, the following are dealt with, viz., the Weston Voltmeter; Elihu Thomson's instrument for reading both volts and amperes; Karl Lehner's hot wire voltmeter; electrostatic voltmeters by Voysey, Elihu Thomson, and Weston respectively; Weston's Wattmeter; electrodynamometer by Elphinstone and Heap; J. H. Barker's recording apparatus; and Siemens' methods in connection with three-phase currents.

1502. *Evershed Moving Coil Instruments.* (Electrician, 44. pp. 664–665, March 2, 1900.)—A description is given, and the difficulties which require to be overcome in this type of instrument are pointed out.

1503. *Geissler Tube Stratifications.* **H. Pellat.** (Comptes Rendus, 130. pp. 323–325, Feb. 5, 1900.)—Experimental research, and conclusions adverse to the idea of stratification being due to anything of the nature of stationary vibrations by reflection and interference. A. D.

1504. *Molecular Magnetic Susceptibilities.* **H. du Bois** and **O. Liebknecht** (Deutsch. Phys. Gesell., Verh. 1. 12. pp. 236–240, 1899.)—A paper similar to those referred to in Abstracts Nos. 523 and 869 (1900). E. E. F.

1505. *Magnet Steel.* **O. Lang.** (Zeitschr. Instrumentenk., Beib. 20. pp. 185–187, and 21. pp. 192–193, 1899.)—These papers contain the results of experiments on the magnetisation of different steels, particularly those containing manganese or nickel, or both, in various percentages. The experiments show the particular method of hardening which gives the maximum magnetisation for each specimen tested.
J. B. H.

1506. *Secular Variations of Magnetic Inclination.* **Folgheraiter.** (Journ. de Physique, 8. pp. 660–667, 1899. Extract from the Archives des Sciences Physiques et Naturelles, 8. p. 5, 1899.)—The author has in several previous papers [see 1899, Abstracts Nos. 839, 1039, 1734] described a method of determining past values of the magnetic inclination from observations of various kinds of earthenwares. The present paper is a more complete and connected statement of his work. C. P. B.

1507. *Transformer Currents under Wehnelt Interrupter.* **O. M. Corbino.** (Accad. Lincei, Atti, 9. pp. 102–107, Feb. 18, 1900.)—This is an experimental research into the sound from the interrupter, the aspect of the anode, the mean strength of the primary current, the form of the curve of the secondary current, the mean strength of the secondary current when this is unilateral, and the form in that case, all under various conditions. A. D.

1508. *Conductivities of Certain Media for a Steady Flux.* **C. H. Lees.** (Phil. Mag. 49. pp. 221–226, Feb., 1900.)—The case worked out, with diagrams, is of a medium formed of an equal number of infinitely long prisms of square cross-section, of two media having conductivities k_1 and k_2, arranged chess-board fashion (on cross-section), and bounded by two parallel equipotential planes drawn through diagonals of cross-sections of the prisms. A. D.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1509. *Seventh Annual Report of the Committee on Atomic Weights.* **F. W. Clarke.** (Chem. News, 81. pp. 146–147, March 30, and 160–161, April 6, 1900; Journal of the American Chemical Society, vol. xxii., No. 2.)—The report summarises researches on atomic weights published in 1899, the elements referred to being Mo, W, Ce, Pd, B, N, Ca, Ni, and Co. The experiments of Curie have shown that radium has a higher atomic weight than barium, although its exact value is unknown [see 1900, Abstract No. 68]. The electro-chemical equivalents of copper and silver have been reinvestigated by Richards, Collins, and Heimrod [see 1900, Abstract No. 889]; the research is to be continued. A complete table of atomic weights is given. This includes the values adopted by the committee according to the two fundamental standards $H=1$ and $O=16$; those of Richards, revised for 1899; and those adopted by the German Chemical Society. Hardin's work on palladium and tungsten, and Kölle's research on cerium, have led to the only notable changes from last year. N. L.

1510. *Atomic Weights and that of Oxygen.* **E. W. Morley.** (Science, 11. pp. 281–288, Feb. 23, 1900. The President's address to the New Haven meeting of the American Chemical Society.)—After reviewing recorded values and their probable limits of error, it is pointed out that all of them rest solely on one single combination, that of hydrogen and oxygen, on their weights, or on the determination of their densities and volumetric ratio, so that all may be subject to some common error. Further work is desirable on the density of hydrogen, avoiding the use of stopcocks; also on the ratio of the combining volumes of H and O, with new precautions. But before the present value of oxygen can be received with confidence, the direct relations between H and Cl or the metals, and those between O and the metals or chlorine, must be redetermined, so that the atomic weight of oxygen may be arrived at by an independent method. S. R.

1511. *Atomic Theory from the Chemical Standpoint.* **H. N. Stokes.** (Science, 11. pp. 601–608, April 20, 1900. Paper read before a joint meeting of the Chemical and Philosophical Societies of Washington, Nov. 25, 1899.)—The author discusses the essential properties of atoms as indicated by the laws of constant and of multiple proportions, valency, &c. He calls attention to the fact that chemical laws give us no information as to the absolute nature of the atoms—that is, as to their further divisibility, unalterability, indestructibility, form, or origin; to the chemist atoms are merely centres through which energy manifests itself. A consideration of valency and isomerism, however, shows that the atoms in a molecule are combined in such a manner that there is a more intimate relation between some atoms than between others, this finding expression in structural formulæ. Further, stereo-chemical phenomena indicate that the molecule possesses a certain definite, geometrical structure, not necessarily rigid, but with no mobility of its parts analogous to that existing in the solar system. T. H. P.

1512. *Objections to the Atomic Theory.* **F. K. Cameron.** (Science, 11. pp. 608–612, April 20, 1900. Paper read before the joint meeting of th

Chemical and Philosophical Societies of Washington.)—The author discusses the case of the atomistic *versus* the mathematico-physical method of regarding matter and energy. He argues that the atomic constitution of matter, although yielding a sufficient explanation of the laws of chemical combination, is yet by no means a necessary consequence of those laws. It is pointed out that the atomic hypothesis is nothing more than an analogy with a conceivable mechanical process; as instances of the downfall, after long persistence, of such mechanical explanations of phenomena are cited the corpuscular theory of light and its successor, the undulatory theory, the hypothetical ether of the latter having been shown by Kelvin to be necessarily unstable and physically non-existent. In accounting for special phenomena the original atomic hypothesis has been modified to meet each specific case, as is evidenced by the notions regarding asymmetric carbon atoms, space isomerides, and polymers generally, varying valency, and complex or "physical" molecules determining the symmetry of crystals. It is admitted that such hypotheses have their uses, but the author points out that a knowledge of the exact relation between any hypothesis and the phenomena which it seeks to explain should be accompanied by a recognition of the retarding influence the hypothesis has had, and may still have, on the development of science. Boltzmann's views—that both the atomistic and mathematico-physical methods of representing phenomena must be regarded simply as methods, each of which possesses its own inherent advantages—are discussed, as also are Volkmann's modifications of them.

T. H. P.

1513. *Periodic Change of Reaction Velocities.* **W. Ostwald.** (Phys. Zeitschr. 1. pp. 87–88; Discussion, pp. 81 and 88, 1899. Report read before the Naturforscherversammlung in Munich.)—Following up the observations of Hittorf [see 1898, Abstract No. 1072, and 1899, Abstract No. 1744], the author has studied more closely the action of hydrochloric acid on chromium, and finds that the velocity of solution is subject to periodic changes of great regularity, as shown by the variations in the amount of gas evolved. The length of the period is decreased when the temperature is raised or the concentration of the acid increased, and is greatly influenced by the presence of other acids and salts. The phenomenon is not observed with pure chromium, and must therefore be attributed to some impurity—very probably sulphur.

In the discussion, **Kohlrausch** referred to a similar periodicity observed in the evolution of gas in the electrolysis of platinum chloride. **L. Wulff** considered that the form of the curve representing the reaction velocity indicated the simultaneous occurrence of two processes having different periods, and thus suggested an analogy with the two well-known modifications of chromium salts.

N. L.

1514. *New Periodic System.* **K. Schirmeisen.** (Zeitschr. Phys. Chem. 33. pp. 223–236, April 17, 1900.)—The basis of this arrangement is the basic or acid character of the elements combined with their chemical activity, the latter property exhibiting a more regular periodic variation as the atomic weight increases than is shown by the valency. The elements are divided into a number of groups, some of them small, containing eight members, and some larger. In the smaller groups the elements are arranged round the circumference of a circle at distances proportional to the excess of their atomic weights over that corresponding to the zero of angular measurement; whilst for the larger groups the members are spread over the circumferences of two

circles placed so as to form a figure 8. This system of classification, which is discussed in detail for the several groups, comprehends all those previously proposed, and presents also the following improvements: It gives a clear representation of the changes in chemical properties among the separate members of each family—for example, the passage from acid to basic characters in the principle members of the fourth and fifth families; also it takes account of hydrogen, finds a place for copper, silver and gold, and explains special properties of separate elements, such as germanium and thallium. Further, it brings out the relation between the occurrence of coloured ions and the diminution in chemical activity and basic properties, and shows the probable existence of end-members in certain of the element-groups. The one arbitrary feature of the scheme is the determination of the atomic weights corresponding to the zeros of angular measurement for the various families. The author expresses the opinion that the chemical behaviour of the elements is conditioned by other variables besides valency, activity, and basic or acid character, and that in a complete representation of the affinity relations such other variables will have to be taken into account. T. H. P.

1515. *Cicatrisation of Crystals.* **C. Maurain.** (Journ. de Physique, 9. pp. 208–212, April, 1900.)—If a new face be produced on an alum crystal by filing, this face will disappear when the crystal is allowed to grow in an alum solution, faces parallel to those of the original crystal being formed. This healing process, however, varies according as the new face is, or is not, compatible with the symmetry of the crystal; in the former case, the face becomes first converted into a well-polished natural face and then disappears, whilst in the latter, the artificial face becomes covered with a convex deposit bounded by those natural faces coinciding most nearly with that face, this deposit then gradually disappearing under the symmetrical overgrowth. Experiments on the influence of the solvent medium on the crystalline form of potassium nitrate, sodium chloride, camphor, and mercuric chloride allow of no general conclusion being drawn. It appears, however, that when a drop of a solution is evaporated on a glass slide there is always a marked difference between the crystals formed at the edge of the drop and those formed in the interior; also crystals formed by sublimation have their edges rounded by evaporation just as ordinary crystals do when immersed in an unsaturated solution. T. H. P.

1516. *Coal Analysis.* (Elect. Rev. 46. p. 461, March 16, and pp. 504–505, March 23, 1900.)—This article is a digest of the report on coal analysis issued by the American Chemical Society. The first point on which emphasis is laid is the sampling. This must be done with great care, and the final samples carefully sealed in air-tight receptacles to obtain the correct moisture determination. The moisture is best determined by drying a finely ground sample in an open crucible at 104–107° C. To obtain this temperature a double wall bath containing toluene is recommended. Drying in vacuo over strong sulphuric acid probably gives more accurate results; but the error, which is not more than 0·37 per cent., does not render such a method necessary, seeing that the errors in sampling are likely to be far greater. The point to be observed is that the coal must be dried at a temperature above 100° C. For coals with less than 2 per cent. moisture, drying over sulphuric acid at atmospheric pressure for twenty-four hours is satisfactory; but this method is no use for lignites or coals with a high moisture percentage.

The volatile combustible matter is tested by rapidly heating a sample in a tightly covered platinum crucible over a Bunsen burner. The difference between the loss in weight from moisture determination and this gives the required figure. Slow heating gives the yield of coke too high. The ash is determined by slowly consuming coal in an inclined crucible. The sulphur is found by Eschka's method, particulars of which are given, as also of an alternative method, viz., Atkinson's.

Examples of the comparison between the heating effects as calculated from the analysis and as found by the calorimeter are given. J. L. F. V.

1517. *Physico-Chemical Studies of Tin.* **E. Cohen.** (Zeitschr. Phys. Chem. 33. pp. 57–62, April 3, 1900; compare Abstract No. 878, 1900.)—A photograph is given showing the partial conversion of a block of Banca tin into the grey modification when innoculated with grey tin and kept at a temperature of $-5°$ during three weeks. The conversion of white tin into grey tin has usually been noticed only when it has been submitted to very low temperatures, *e.g.*, during a very severe winter; but since the transition-point is above the atmospheric temperature the same change should take place also under normal conditions, although exceedingly slowly. This conclusion is fully borne out by the observations of Gowland on some pewter vessels discovered near Andover by Engleheart in 1897, and now in the British Museum; they contain 94·35 per cent. of tin and 5·06 per cent. of lead, and have probably been buried since 350 A.D., and during this period have been very largely converted into grey tin.

A table is given showing the velocity of change of grey tin into white tin at temperatures between 30° and 35°. T. M. L.

1518. *Vapour Density of Bromine at High Temperatures.* **E. P. Perman and G. A. S. Atkinson.** (Zeitschr. Phys. Chem. 33. pp. 215–222, April 17, 1900.)—The vapour density of bromine has been determined at a number of temperatures between 600° and 1,050°. Normal values were obtained up to 750° under atmospheric pressure, but at this point dissociation begins, and at 1,050° the density falls to 75·25. The dissociation constants are calculated to be as follows:—

T	800°	850°	900°	950°	1,000°	1,050
γ	13,320	8,630	1,750	620	264	110

T. M. L.

1519. *Colloidal Metals.* **A. Lottermoser.** (Phys. Zeitschr. 1. pp. 148–149, 1899. Report read before the Naturforscherversammlung in Munich.)—The quantity of normal acid required to completely precipitate colloidal silver from its solutions is found to be inversely proportional to the strength of the acid. Alkali and ammonium salts of acids forming soluble silver salts, when added to colloidal silver solutions, throw down the colloidal metal, whilst other salts yield ordinary insoluble silver. Reducible metallic chlorides, however, are converted into lower chlorides, silver chloride also being formed; and, in this case, if the reacting solutions are very dilute, the chlorides often remain in solution in the colloidal state. By the addition of solutions of the halogens, colloidal silver is transformed into the colloidal silver haloids, and these latter are also precipitated by all electrolytes. These precipitations do not take place in presence of a stable colloid, such as gelatine or albumen, until the latter is all thrown down. The authors have also obtained colloidal mercury, bismuth, and copper, which are prepared by reducing salts of these metals by means of stannous salts. T. H. P.

1520. *Catalytic Action, and Hydrolysis of Polysaccharides and the Decomposition of Esters.* **O. Šulc.** (Zeitschr. Phys. Chem. 33. pp. 47–56, April 3, 1900.)—Experiments were made on the influence of finely divided palladium on the hydrolysis of saccharose, maltose, and raffinose by water and dilute acids, and on the effect of palladium, osmium, rhodium, iridium, copper, silver, and mercury on the hydrolysis of amyl and isobutyl acetates by water at 100°. In every case a retarding action was observed, iridium being as a rule the most, and mercury the least, active in this respect. The results obtained are illustrated by curves. N. L.

1521. *Gold-Aluminium Alloys.* **C. T. Heycock** and **F. H. Neville.** (Roy. Soc., Proc. 66. pp. 20–21, Feb., 1900; Roy. Soc., Phil. Trans. 194. pp. 201–232, April 11, 1900.)—This paper contains the results of a study of the alloys of gold and aluminium, the freezing-point method being combined with a microscopic examination. The freezing-points of mixtures varying in composition from pure gold to pure aluminium are given, and the equilibrium curve for the liquid alloys and the various solids separating from them thus obtained. The authors' method of working is as follows: The freezing-point of pure gold is first determined by means of a platinum resistance pyrometer of the Callendar-Griffiths type, successive roughly weighed quantities of aluminium then being added and the freezing-point taken after each addition; a portion of each alloy is sucked up from the thoroughly molten and stirred metal by means of a Jena glass pipette, the rods of metal thus obtained being used for analysis and microscopic study. The curve having for ordinates the freezing-points and for abscissæ the corresponding atomic percentages of aluminium in the alloy consists of seven branches, each indicating a state in which a particular solid crystallises first. In the solid alloys obtained the following seven distinct substances are detected: Gold; Au_4Al; Au_5Al_2 or Au_8Al_3; Au_2Al; AuAl (?); $AuAl_2$, the beautiful purple alloy discovered by Roberts-Austen; aluminium. The melting-points of the alloys, all of which, except $AuAl_2$, have a pure white colour, are: Au_2Al, 625°; $AuAl_2$, 1,062°, identical with that of pure gold; Au_5Al_2 or Au_8Al_3, 575°; Au_4Al, about 550°; the melting-point of AuAl is not furnished by the curve. There are three well-defined eutectic points: (1) at 527°, corresponding to a mixture of Au_4Al and Au_5Al_2, containing 3·6 per cent. by weight of aluminium; (2) at 569°, for an alloy containing Au_2Al and AuAl with 8·36 per cent. of aluminium; (3) at 648°, the alloy being a mixture of $AuAl_2$ and Al, containing 1·87 per cent. of gold. The lowest melting-point is hence possessed by a mixture containing only 3·6 per cent. by weight of aluminium, which depresses the melting-point of gold from 1,062° to 527°. Each eutectic point gives rise to a horizontal row of second freezing-points in the curve, and mixtures containing more than 44 per cent. and less than 60 per cent. of aluminium have three distinct freezing-points corresponding to the successive separation of three solid alloys. Photomicrographs are given of polished and etched sections of alloys of different composition, and these show that the structure of the solid alloy is in all cases in concordance with the indications of the freezing-point curve. The type of pattern of the etched surface depends on the position of the corresponding freezing-point on the curve, and in general these types are repeated at corresponding points of each branch of the curve. Thus, near a maximum point, which is the melting-point of a pure alloy, almost the whole surface of the section is filled with more or less hexagonal polygons; a little below the summit these polygons become separated by a ribbon-like network of mother substance, and still further down

the curve the crystals of pure alloy are less numerous and are arranged in regular patterns, showing that they are the result of free crystallisation while surrounded by liquid; finally, at the eutectic point, no crystals are found, the whole field of the microscope being occupied by the mother substance. Some of the alloys rich in aluminium are photographed by means of the Röntgen rays, an enlarged positive being made from the negative. By this means the structure of the alloy is shown much more clearly than by an ordinary surface photograph. T. H. P.

1522. *Chemical Dynamics of Benzene Bromination.* **L. Bruner.** (Acad. Sci. Cracovie, Bull. 1. pp. 29–37, Jan., 1900.)—The author seals up in test-tubes weighed quantities of bromine (sealed up in small bulbs) and benzene, with or without iodine. The reaction is started by breaking the bromine bulbs, and followed by titration of the free bromine with potassium iodide, and thiosulphate. With equivalent quantities the reaction proceeds asymptotically towards completion, *i.e.*, complete formation of monobrombenzene, but no velocity-constant could be obtained. Using 3 mols. benzene to 1 mol. bromine, a constant was obtained assuming a bimolecular reaction with equivalent quantities, but no satisfactory constant for the monomolecular or general bimolecular reaction. The experiments show further the great accelerating influence of iodine—an amount equal to 1 per cent. of the benzene increasing the velocity-constant tenfold. F. G. D.

1523. *Equilibria in the System, Water—Phenol—and d-Tartaric Acid or Racemic Acid.* **F. A. H. Schreinemakers.** (Zeitschr. Phys. Chem. 33. pp. 74–77, April 3, 1900.)—It is shown that dextro-tartaric and racemic acids have the same influence on the formation of two liquid layers in mixtures of water and phenol. F. G. D.

1524. *Equilibria in the System, Water—Phenol—Acetone.* **F. A. H. Schreinemakers.** (Zeitschr. Phys. Chem. 33. pp. 78–98, April 3, 1900.)—This system is of interest inasmuch as the binodal curve possesses a closed form between 68° and 92°, or in other words, if the composition of any complex be indicated by a point on a triangular diagram, then between 68° and 92° the composition of those mixtures which separate into two liquid phases will be indicated by points lying within a closed curve. The paper contains full experimental details and a useful summary of the results arrived at by the author in this and previous investigations on ternary systems possessing two or three coexistent liquid phases. F. G. D.

1525. *Decomposition of Sodium Thiosulphate by Acids.* **H. v. Oettingen.** (Zeitschr. Phys. Chem. 33. pp. 1–38, April 3, 1900.)—When an acid is added to a solution of sodium thiosulphate the liquid remains clear for a time, and then suddenly becomes turbid owing to the separation of sulphur. The author describes experiments made to determine the influence of the nature and quantity of the added acid on the reaction and also to ascertain whether any real difference exists between the metastable and the labile conditions of a supersaturated solution. When acids of different strengths are employed the increase in the time elapsing between mixing and separation of sulphur is proportional to the square of that time and to the decrease in the concentration of the hydrogen ions, and varies inversely as this concentration; the law connecting the time and the concentration of the hydrogen ions is hence a logarithmic one. Parallel experiments with hydrochloric, oxalic,

dichlor- and trichlor-acetic acids show that the nature of the acid influences the time required for the separation of sulphur only in so far as the acid is more or less dissociated; for isohydric solutions of these acids the times are equal. The addition of sodium sulphite to the solution hinders the precipitation of sulphur, but the relation between the time and the concentration of hydrogen ions remains a logarithmic one. No definite equilibrium relations can be determined for the reaction, thiosulphate = sulphite + sulphur, owing to the secondary reaction between the thiosulphate and sulphite. The moment at which separation of sulphur takes place cannot be detected by means of conductivity determinations of the mixed solutions, nor do such measurements decide the question of the existence of a "metastable limit." Not only the precipitation of sulphur but also the further course of the reaction is a function of the concentration of the hydrogen ions of the acid. The velocity of decomposition of sodium thiosulphate has the same value for isohydric solutions of different acids. T. H. P.

1526. *Internal Pressure of Aqueous Salt Solutions.* **A. Heydweiller.** (Phys. Zeitschr. 1. pp. 114–116, Dec. 2, 1899.)—The internal pressures of aqueous salt solutions have been calculated from—(1) The capillarity constant; (2) the compressibility; (3) the change of volume during the solution; (4) the change in the heat capacity. The concordance between the results obtained is shown in the table, which gives the pressure in atmospheres at different concentrations by the four methods:—

	NaCl.				KCl.			
m	p_1	p_2	p_3	p_4	p_1	p_2	p_3	p_4
0·5	118	106	108	135	—	72	108	184
1·0	223	261	211	207	223	166	222	327
1·5	328	453	309	261	320	308	317	501
2·0	433	620	397	305	414	440	405	612
3·0	689	865	566	—	638	649	577	709
4·0	931	1,100	720	—	859	790	784	—
5·0	1,212	1,381	861	—	—	—	—	—

The deviations are regarded as due in part to experimental errors and in part to the fact that the assumptions which form the basis of the calculation do not hold accurately. T. M. L.

1527. *Solubility of a Mixture of Salts possessing a Common Ion.* **C. Touren.** (Comptes Rendus, 130. pp. 908–911, April 2, 1900.)—The author has determined the solubility curves and quadruple points for the following pairs of salts at 14·5° and 25·2° respectively: KNO_3, KCl; KNO_3, KBr. He finds that equivalent solutions of chloride and bromide have an equal effect in lowering the solubility of the nitrate, and concludes from that that they are equally dissociated. F. G. D.

1528. *Mechanism of Gelation in Reversible Colloidal Systems.* **W. B. Hardy.** (Roy. Soc., Proc. 66. pp. 95–109, March 22, 1900.)—The author distinguishes three forms in which colloidal matter can occur, viz.: (1) Fluid mixtures, or colloidal solutions (Graham's *sols*). (2) Solid mixtures of fluid and solid (Graham's *gels*). (3) Solids, such as dry silica or glass. The change

from the sol to the gel may be reversible, as in the case of gelatine and water, or irreversible, as in the case of silica and water. The three-component system, gelatine-water-alcohol, is particularly amenable to experimental study, as it forms two phases which differ greatly in refractive index. Clear homogeneous solutions separate on cooling into two phases, the temperature at which this occurs depending on the composition of the mixture. These phases are at first fluid; but on further cooling, one becomes solid (solid solution), the surface of separation being curved and discontinuous. The solid solution phase is formed sometimes on the concave, sometimes on the convex side of the interface, according as the proportion of gelatine is small or large. Thus a hydrogel may consist of a solid mass containing spherical fluid droplets or of solid droplets attached to each other and forming a solid framework which mechanically encloses fluid. The two-component system, agar-water, does not give phases which can be optically distinguished, but the author assumes their existence and seeks to separate them by gentle pressure of the jelly in a long canvas packet. The effects of the ratio of the masses of the two components and of temperature on the composition of the phases are studied. In the latter case hysteresis is observed, analogous to the hysteresis in the vapour pressure-temperature curve of the hydrogel of silica observed by van Bemmelen (Zeits. f. anorg. Chem. 13. 233, 1896). The gel in the case of agar-water should, according to the phase law, form a monovariant system if it contains two phases. The author's experiments prove that the system is apparently not monovariant. This discrepancy is explained as being due to the presence of capillary forces, *i.e.*, to the existence of a large amount of surface-energy in the jelly. In the deduction of the phase law such disturbing factors are expressly excluded. F. G. D.

1529. *Stability of Irreversible Hydrosols.* **W. B. Hardy.** (Roy. Soc., Proc. 66. pp. 110–125, March 22, 1900.)—The author investigates certain systems which he prepares as follows: (1) Hydrosol of gold. Addition of two drops of ether solution of phosphorus to a litre of dilute chloride of gold solution. Dialysed for fourteen days and then concentrated by boiling. (2) Hydrosol of silicic acid. Addition of excess of hydrochloric acid to a solution of soluble glass and dialysing. (3) Hydrosol of ferric hydrate. Dialysis of the solution in ferric chloride. (4) Hydrosol of gum mastic. Addition of dilute solution of gum in alcohol to water and dialysing. (5) Hydrosol of heat-modified egg-white. Dissolving egg-white in nine times its volume of distilled water, filtering, boiling, and then dialysing.

These systems are regarded as suspensions. The author finds that the stability decreases as the *iso-electric point* is approached, *i.e.*, the point when the particles do not move in an electric field. This is proved by experiments with the proteid solution, where by addition of acid or alkali the *sign* of the charge can be changed, and so the zero point approached from either side.

Experiments on the coagulative power of salts confirm previous work and establish the following relation: "The coagulative power of a salt is determined by the valency of one of its ions. This prepotent ion is either the positive or negative ion according to whether the colloidal particles move down or up the potential gradient, *i.e.*, the coagulating ion is always of opposite electrical sign to the particle."

Defining specific molecular coagulative power, K, as the dilution in c.c. per gramme-molecule of a substance which just suffices to produce coagulation, then K varies with the valency of the active ion according to the law, $K : K^2 : K^3 = R' : R'' : R'''$. In practice this relation is complicated by the

change which the specific molecular conductivity of the salt undergoes with varying concentration. For acids and alkalies the case is different. If the particles are electro-positive, acids either have no precipitating power or else this power varies with the valency according to above law. For alkalies K varies with the chemical activity of the solution. If the particles are electro-negative then alkalies either have no effect or the value of K does not vary in any simple manner with the valency. For acids K varies with the chemical activity of the solution. By "chemical activity" is here understood the value of $a(u+v)$ for any concentration, where $a=$ degree of ionisation and $u+v=$ specific molecular conductivity at infinite dilution. F. G. D.

1530. *Chemical Reactions in Solution. Vapour Pressure of the Solvent.* **A. Ponsot.** (Comptes Rendus, 130. pp. 782–785, March 19, 1900.)—This is a thermodynamical note in which the author by considering certain cyclical isothermal processes arrives at the following results: "When spontaneous and balanced reactions occur at constant temperature and pressure between the dissolved or mixed constituents of a homogeneous or heterogeneous system, then (1) they increase, up to a certain maximum value, the vapour-pressure of the solvent, provided the latter takes no part in the reaction; (2) they increase, up to a certain maximum value, the vapour-pressure of one of the reacting substances, when this body is produced in the reaction and *vice versâ.* F. G. D.

1531. *Solution Pressure.* **S. R. Milner.** (Phil. Mag. 49. pp. 417–423, May, 1900.)—This paper gives a thermodynamical proof of Nernst's equation for the contact difference of potential between a metal and an electrolyte. By means of vessels separated by semi-permeable partitions, the author has devised a circuit in which the thermodynamic cycle is reversible, and in which the phenomena at the electrodes can be considered separately. The expression he obtains is—

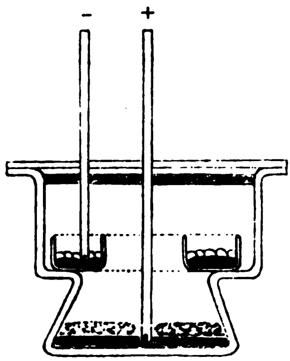
$$\phi=\frac{1}{n\epsilon}\int_{P}^{p_1} v\,dp,$$

from which Nernst's formula immediately follows by applying the gas law $pv=RT$.

If the electrolyte is not completely ionised, it is usually taken for granted that the only effective pressure in producing the potential step is that of the metallic ions. This is here shown to be thermodynamically correct if the isotherm of ionisation is taken to be that given by the law of mass action. Nernst's formula depends for its validity only on the osmotic pressure and ionisation theory, and on the reversibility of the electrolytic solution and deposition of the metal at the electrode. J. B. H.

1532. *Electrolytic Estimation of Manganese in Manganese Ore.* **A. Hiorns.** (Chem. News, 81. p. 15, Jan. 12, 1900.)—The solution of the ore, containing not more than 0·03 gm. of manganese, is made strongly acid with nitric acid, placed in a weighed platinum dish which is connected with the positive pole of a Bunsen cell, and electrolysed for twelve hours at a temperature kept as near 60° C. as possible. A platinum wire spiral dipping into the liquid is used as the kathode. The deposit of MnO_2 is washed with water, dried, converted into Mn_3O_4 by ignition, and finally weighed. N. L.

1533. *Practical Form of Normal-Element and Normal-Electrode.* **E. Bose.** (Zeitschr. Elektrochem. 6. pp. 457–459, March 1, 1900.)—The normal element shown in the figure is made by inserting a ring-shaped vessel into an ordinary desiccator glass, and has the advantages that (1) the electrode surfaces are very large, and the current-lines are very largely vertical, so that the electrodes are only very slightly affected by the passage of a fairly large current; (2) if only a small amount of crystal is present the internal resistance is very small. In all cases the mercury, covered with a layer of



Hg_2SO_4, is placed at the bottom, whilst the ring contains solidified Zn or Cd amalgam covered with crystals of zinc or cadmium sulphate. The solution of zinc or cadmium sulphate is covered with a layer of liquid paraffin.

For use as a normal electrode both electrodes are made of (*e.g.*) mercury covered with calomel, and a dropping funnel is fitted into a third aperture in the cover; contact is made with the N/10 KCl solution, which fills the vessel, by means of a side tube fitted to the dropping funnel; any change in the condition of the electrode due to the passage of a current can then be immediately detected by changing from one electrode to the other. T. M. L.

1534. *Electrolytic Preparation of Indulin Dyes.* **W. Löb.** (Zeitschr. Elektrochem. 6. pp. 441–442, Feb. 22, 1900.)—A preliminary note. Results similar to those described by Szarvasy (see 1900, Abstract No. 1126), have been obtained by the kathodic reduction at the ordinary temperature of a solution of aniline and various nitro-compounds in concentrated hydrochloric acid. N. L.

1535. *Electrolysis of Sodium Chloride.* **R. Lorenz** and **H. Wehrlin.** (Zeitschr. Elektrochem. 6. pp. 389–392, Jan. 25; 408–410, Feb. 1; 419–428, Feb. 8; 437–441, Feb. 22; 445–452, March 1; and 461–464, March 8, 1900.)—In this long paper a detailed account is given of an investigation, commenced in 1896, the main lines of which have been indicated in a previous note by Lorenz (Zeitschr. Elektrochem. 4, 247). Most of the results have meanwhile been anticipated by the work of Wohlwill [Abstracts Nos. 341 (1899); and 268 (1900)]; and Foerster [Abstracts Nos. 1946 (1899); and 269 (1900)]; hence no claim to novelty is made, except as regards minor details. The bulk of the paper is unsuited for abstraction, but the primary process at the anode, both in neutral and alkaline solutions, is considered to be the formation of hypochlorite from chlorine and sodium hydroxide. When, however, the electrolytic back E.M.F. at the anode appreciably exceeds the E.M.F. of polarisation,

chlorate begins to be formed at the expense of the hypochlorite. The authors incline to Wohlwill's opinion that in this latter process hydroxyl ions play an important part. N. L.

1536. *Metals Deposited under Electric Transport.* **T. Tommasina.** (Comptes Rendus, 130. pp. 325–327, Feb. 5, 1900.)—Chains of metal particles, electrolytically deposited and running from one electrode to another in distilled water, give rise in many cases to the formation of beautiful crystals, or sometimes of crystalline arborescences or velvety deposits. The chains of minute crystals may form conductors from electrode to electrode, flexible enough to show Ampere's law by their displacement: and the chains are themselves formed along the lines of force. A. D.

1537. *Electrolytic Production of Copper Tubes.* **S. Cowper-Coles.** (Inst. Elect. Engin., Journ. 29. pp. 258–279; Discussion, pp. 279–285, March, 1900.)—The author describes a process he has invented and named the "Centrifugal" process for production of copper tubes. In this, a *vertical* mandrel in rapid rotation is used as kathode, and the friction of the electrolyte upon the surface of the mandrel is claimed as rendering it possible to obtain smooth and dense deposits of copper at the kathode with current densities up to 190 amperes per square foot. The E.M.F. required with raw copper anodes varies from 1·0 to 1·2 volts. The electrolyte is filtered before entering the cell, and is kept in rapid circulation through it. It should contain 22·44 oz. copper sulphate (crystals) per gallon, and from 15·0 to 22·34 oz. free sulphuric acid. The former amount of free sulphuric acid is, however, the best. The electrolyte should be maintained at 150° F. Unannealed copper sheet deposited by this method showed a tensile strength of 22·1 tons per square inch. A large number of physical data and other figures relating to copper are contained in the paper, gathered from various sources of information.

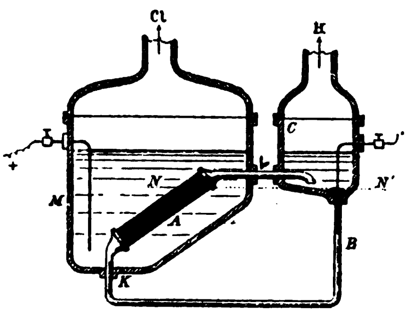
In the discussion several speakers referred to processes similar to the author's, and already in use or previously described.

In his reply the author maintained the originality of his method, on the ground that none of the previous workers in this field had recognised the existence of a critical speed of rotation. Below this speed only ordinary deposits of copper are obtained at the kathode; above it, smooth and dense deposits are obtained. The critical peripheral speed is below 1,000 feet per minute. J. B. C. K.

1538. *Mercury Vats for Electrolytic Alkalies and Chlorine.* **J. B. C. Kershaw.** (Elect. Rev. 46. pp. 606–607, April 13, 1900.)—The author first gives some general information as to the two most important systems now in use, *i.e.*, the Castner-Kellner and the Rhodin system. An account is then given of the invention of two Italians, H. Grudo and J. Bisazze, and their Italian patent of December 13, 1899. In this cell there is a reversal of the disposition of kathode and anode, in such a manner that the under surface of the mercury is the active part of the kathode, and as the amalgam forms it rises through the supernatant mercury, the necessity of moving the mercury kathode being thus obviated. Ferrous sulphide is placed in the negative department of the cell, and is said to accelerate the decomposition of the mercury amalgam by water. The cause of this reaction is not quite clear, but is ascribed, by the author, to the fact that the ferrous sulphide acts as the negative element of an electrical couple.

Four different forms of cells are then described in detail for carrying out

the process on the lines indicated. Hydrogen comes off with the chlorine, which is ascribed by the inventors to the decomposition of water, and by the author to the decomposition of a portion of the amalgam on the lower side of the mercury kathode. The figure shows the form of cell which has been designed to overcome this defect. A is a porous tube containing the mercury, and connected with the kathodic compartment of the cell by the non-porous tubes B, K, and L. The amalgam formed in A is displaced by gravitation, and slowly rises and passes over into C—this upward movement being also assisted by any hydrogen that may be liberated in the tube A. In C the amalgam is at once decomposed by its contact with ferrous sulphide and water, and the regenerated mercury finds its way back into A, by the tubes B and K. The enclosure of the mercury in a porous kathode tube, and the inclination of this tube in the anodic compartment of the cell in the manner shown, thus causes both the hydrogen and the amalgam to be carried into the decomposing chamber by a movement which is perfectly automatic in



character; and the chlorine passing from the anodic compartments of the cell, is entirely free from hydrogen.

The disadvantages of the cell, in the author's opinion, are the use of a diaphragm with its accompanying drawbacks of increased internal resistance. Current efficiency of 95 to 100 per cent. are stated to have been obtained, but no figures as to E.M.F. required are obtainable.

Another cell, the invention of J. W. Kynaston (Eng. Pat. No. 15967 of 1898) is then explained. This is a vertical cell, in which the mercury flows zigzag fashion over narrow shelves affixed to the sides, being discharged by a pipe at the bottom. The successive shelves are supplied with transverse ridges and run-off pipes at alternate ends. Each shelf is thus constantly covered with a layer of mercury ⅜ inch deep, and only the lighter amalgam passes off from it to the one below. Between these mercury shelves the vertical carbon anode is placed. The mercury amalgam is drawn off at the bottom of the cell, is decomposed in a separate vessel, and then returned to the cell. O. J. S.

1539. *Electrolytic Production of Bleaching Solutions.* **F. Foerster.** (Ind. Électrochim. 4. pp. 4–9. Jan., and 18–20. Feb., 1900; from Moniteur Scientifique, p. 90, 1900; and Die Chemische Industrie, Nov. 15, 1899.)—A lengthy article, in which the author deals, first with the chemistry of the process, and secondly with a few of the special forms of cell designed for its industrial application. In the first part the work of Fogh, Oettel, Haber and Grinberg, Bischoff and Foerster, Wohlwill, Jorre and Foerster, Müller, and of Sieverts is made use of, and the advantages and disadvantages of the various methods

for lessening the losses due to reduction by hydrogen at the kathode are discussed. The author states that Müller's suggested addition of chromium salts cannot be adopted in the production of bleaching solutions, owing to the necessity for keeping such solutions colourless. The presence of free hypochlorous acid in certain electrolytic bleach solutions is explained by the use of salts of calcium or magnesium in the electrolyte, and by the insoluble form in which these metals are separated at the kathode. As free hypochlorous acid is of higher bleaching value than its salts, its determination *separately* by Jorre's method is requisite, when testing such solutions for active chlorine.

Dealing with the industrial preparation of bleaching solutions by electrolysis, the author decides in favour of cells having a large number of secondary electrodes, and thus capable of utilising currents of high E.M.F. A detailed description of the Kellner cell, with its "point" electrodes, is given. The chief disadvantage of this cell is its high cost, due to the platinum which it contains; and on this account attempts have been made by other inventors (notably Haas and Oettel) to utilise carbon for the electrodes. Carbon is, however, attacked to some extent by the oxygen of hypochlorites, and a loss of efficiency thus results. In time the author thinks some form of carbon may be produced, which will be more resistant in such solutions. The article closes with an unfavourable criticism of the original form of Hermite cell.

J. B. C. K.

REFERENCES.

1540. *Freezing-Point Methods in Dilute Solutions and the Theory of Solutions.* **M. Wildermann.** (Zeitschr. Phys. Chem. 32. pp. 288-302, Feb. 20, 1900. See 1900, Abstract No. 675.)—A controversial paper. The results of Dieterici (see 1898, Abstract No. 818) and the position taken up by him with regard to this subject are severely criticised. The work of Raoult (see 1899, Abstract No. 858) and of Loomis (see 1900, Abstract No. 884) is also referred to.

T. H. P.

1541. *Solubility of Gases in Water.* **W. French** and **F. Ashworth.** (Chem. News, 81. p. 13, Jan. 12, 1900.)—The author describes a simple form of apparatus, constructed of two or three burettes, by means of which the solubilities of the more sparingly soluble gases may be demonstrated with considerable accuracy by class students.

N. L.

1542. *Influence of Water on the Combustion of Carbon Monoxide. A Plea for Contact Action.* **G. Martin.** (Chem. News, 81. pp. 25-27, Jan. 19, 1900.)—A theoretical paper in which Dixon's views are criticised. Mainly of chemical interest.

N. L.

1543. *Progress of Electro-chemistry.* **H. R. Kingman.** (West. Electn. 26. pp. 152-153, March 10, and 177-178, March 17, 1900. Paper read before the Chicago Electrical Association, March 2, 1900.)—The author gives brief summaries of the work of Arrhenius, van't Hoff, Nernst, and Ostwald, and points out the relation of this to modern theories of electro-chemical change. Under the head of chemical manufactures he describes at length the Le Sueur process for the production of alkalies and bleach, and less fully the Castner-Kellner and Solvay processes for manufacture of the same chemicals. Under the head of Electro-metallurgy details of the Hall process for aluminium production are given, and some space is devoted to methods of electro-galvanising. The closing section of the paper deals with primary and secondary batteries.

J. B. C. K.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

1544. *Multiple Cylinder Engines.* **E. Lefer.** (Écl. Électr. 23. pp. 60–61 April 14, 1900; Bulletin de la Société d'Encouragement, 5. (3) pp. 58–117, Jan., 1900.)—The author compares the advantages and disadvantages of expanding steam in more than one cylinder, as compared with expansion in a single cylinder. When steam engines were first employed on a practical scale to drive industrial works the system of expanding the steam in two cylinders was introduced, though the object to be obtained in so doing was not fully appreciated. As the engines in use at that time were beam engines, one of the main reasons put forward was that it gave a more regular turning effort than when a single cylinder was used. It seems, however, looking at the types of engines which followed these, that an effort was made to obtain a wide range of expansion without altering the existing imperfect means of steam distribution.

The author traces the various stages of development of the compound steam engine up to the time when modern research demonstrated its economy, but thinks that in spite of the labours of modern experimenters the information relating to this type of engine is not very complete. He then refers to the advocacy of quadruple and quintuple expansion by some engineers, based on the assumption that the more the difference of pressure, and consequently the fall of temperature, in each cylinder was reduced, the less became the internal condensation and the consumption of steam; experience, however, does not always bear this out, and usually expanding three times is considered sufficient. He refers to the uncertainty that existed as to the correct ratios of cylinder volumes, which to-day usually vary from 2·6 to 3 for the ratio of the intermediate to H.P. cylinder, and thinks that practice has had more to do with determining this ratio than theory.

He then passes on to examine the different methods of utilising the steam in order to give a minimum consumption per I.H.P. To do this he makes use of the same data that he has already employed in a former paper on single cylinder engines; but in order to establish a comparison between multiple cylinder engines and single cylinder engines, he assumes that the expansion of steam follows Mariotte's law, which is far from being the case in multiple cylinder engines. Under these conditions he calculates the steam consumption per I.H.P. per hour, assuming different values for (1) Ratio of cylinder volumes; (2) Cut off; (3) Initial pressure of steam in cylinder; and then compares under these conditions engines on the Woolf system and those with two or three cylinders.

Various tables are given in the paper read before the *Société d'Encouragement,* showing the influence of these several points. If the results for two-cylinder compound engines are examined it will be seen that a diminution of cylinder ratios corresponds (1) To an increase of power developed by the steam in the first cylinder; (2) To a corresponding diminution in the second cylinder; (3) To an increase of the total power developed by the two cylinders; (4) To an increase in the weight of steam condensed in the first cylinder; (5) To a diminution of the weight of steam condensed in the

second cylinder ; (6) But the total amount of water condensed shows no diminution.

A closer investigation seems to show that cylinder ratios varying between two and four are best as regards utilisation of heat. A consideration of the influence of various points of cut-off shows that for a given cylinder ratio there is a point of cut-off corresponding to a minimum consumption of steam.

In the third part of the paper the author discusses a number of diagrams taken on multiple cylinder engines, and compares the results of this examination with his calculations. He concludes by stating that although it is true that by employing two or more cylinders to expand the steam in, the fall in temperature in each is reduced, and consequently the internal condensation should fall too ; yet, on the other hand, the cooling surface in contact with the steam is increased, so that what is gained by decreasing the range of temperature is more than counterbalanced by the increase of surface in contact with steam. It is from this cause that the steam consumption of a compound engine may be higher than that for a single cylinder engine. He considers that the loss from condensation is largely due to the difficulties of obtaining the best possible steam distribution with a single slide valve, and it is this that has led to the introduction of improved independent valves on single cylinder engines. L. S. R.

1545. *Ljungstrom's Crankless Engine.* (Engineer, 89. p. 362, April 6, 1900.) —This is a single acting rotary high speed steam engine. Four radial cylinders are fitted with pistons, the trunks of which are provided with wheels which roll round inside an elliptical path. Steam is supplied through a central valve which is stationary, the cylinders revolving round it. The cylinders obtain the steam from the supply port of the valve when the pistons move outwards, and exhaust through the exhaust port of the valve when the pistons move inwards. The turning force of the engine is obtained from the side-thrust given by the pistons when forced by the steam against the outward-going curves of the track. Results of tests made by R. L. Weighton, of Durham College of Science, Newcastle-on-Tyne, are appended. The engine, having four cylinders, $2\frac{3}{4}$ inches diameter × $\frac{13}{16}$-inch stroke, was tested as a high pressure non-condensing engine. The steam coming from the engine was actually condensed for measurement purposes, but no vacuum was formed. Under varying conditions of cut-off the consumption of water per B.H.P. hour varied between 40 and 50 lbs. ; the H.P. was varied from 4·63 at 70 lbs. pressure, cut off at $\frac{1}{4}$, and 1,616 r.p.m., to 18·09 at 180 lbs., cut off at $\frac{1}{3}$, and 1,760 r.p.m. The engine ran satisfactorily, and the consumption of oil was low. L. S. R.

1546. *Present Position of the Steam Engine.* **R. H. Thurston.** (Mech. Eng. 5. pp. 476–480, April 7, and 550–554, April 21, 1900. Paper read before the American Society of Mechanical Engineers.)—The paper traces the progress in steam engine efficiency from the time of Watt to the present day. The losses in our best engines may be to-day taken as usually not far from 20 per cent. thermal and 10 per cent. dynamic. At the beginning of the century they were in Watt's best engines about 60 per cent. thermal and 15–20 per cent. dynamic. The progress of to-day is mainly an improvement of the thermodynamic efficiency by increasing the range of temperature worked through, and by improving the cycle in the direction of a nearer approximation to Carnot's ideal.

The author took part in an official trial of a Nordberg steam pumping

engine, which was expected to exhibit an exceptional efficiency as a consequence of its unusually close approximation to the Carnot cycle. The mechanical arrangements of the engine and pumps are fully described in the paper. Thermodynamically the engine is specially interesting from the fact that the feed heating is done at increasing temperatures throughout, there being four heaters receiving steam from the various receivers. Trials were made with and without the heaters in operation. The duties without and with the heaters were 150,000,000 and 163,000,000 foot lbs. of work respectively per 1,000,000 B.Th.U. supplied. A. S.

1547. *Liquid Fuel.* **H. Guérin.** (Génie Civil, 37. pp. 22–25, May 12, and 36–39, May 19, 1900.)—This subject has recently come afresh before the French Society of Civil Engineers with special reference to the establishment of supply stations for ships of war. Evidence exists of the increased use of liquid fuel in British vessels trading to the Far East, the installation of a charging station at Suez having been authorised by the Egyptian Government, and for railway and other purposes in Russia, America, and other countries. The author refers to articles in vols. 34, 20, 24, 8, 21, 35, and 36 of the *Génie Civil*, and to a paper in the *Engineering and Mining Journal* of New York by H. Tweddle which describes the best methods of using this fuel and of which this article is to some extent a *résumé*. The best results have been obtained by the use of crude petroleum.

The proportions of carbon, hydrogen, and oxygen in various hydrocarbons and their calorific power (in calories per kg.) are given in the following table:—

	C.	H.	O.	Calorific Power.
Light petroleum oil—American	86·894	13·107	—	10,913
Refined	85·491	14·216	0·293	11,047
Petroleum spirit	80·583	15·101	4·316	11,086
Crude petroleum	83·012	13·889	3·099	11,094
Light oil from Baku	86·700	12·944	—	10,843
Petroleum from the Caucasus	84·906	11·636	—	10,328
Ozokerite from Boryslaw	83·510	14·440	—	11,163

To realise the theoretical calorific power and the highest temperature of combustion it is necessary to supply to the combustible the exact quantity of air furnishing the necessary amount of oxygen, and to have the most intimate possible contact between the air and the fuel. Consequently gaseous fuel offers the best conditions for obtaining the best result, liquid fuel the next, and powdered solid fuel the next in order, although in practice excess of air, deposits of soot and other causes prevent more than a moiety of the useful effect being realised, especially in the case of coal firing. The methods of using fuel in the liquid form are, however, the most simple of all, and hence the repeated efforts towards a more general introduction of this kind of fuel.

Various forms of injectors or "pulverisers" which have been from time to time proposed and introduced are enumerated by the author, and the effects of different forms of jets on the completeness of the pulverisation of the oil and its admixture with the air are discussed. The most suitable form of flame for a given furnace or process depends upon the quality of the oil and on the purpose to which the heat of combustion is to be applied.

Tweddle has found by experiment that in order to obtain the highest possible temperature from liquid fuel it is necessary to burn it in fire-brick combustion chambers of limited capacity, and that for evaporative effects an injector worked by steam is preferable to one using an air-jet which is more

suitable for reheating, forge, and other furnaces of that class. The author introduced the use of petroleum fuel on the Oroya Railway in Peru in the year 1890, where experiments had to be conducted under unfavourable conditions. Starting from sea-level at Callao, the railway crosses the Andes at an altitude of 4,250 metres, with a total length of about 160 kilometres. The gradients and curves are consequently against the realisation of a high duty. Nevertheless, the consumption of oil was little over half that of coal for the same work, although the calorific power of the oil as compared with that of the coal was only as 1·4 is to 1.

The apparatus used on this railway is described in detail with illustrations of the burner, or pulveriser, and of the type of furnace employed.

The evaporative effect produced by firing boilers with American petroleum was in 1896 found by the Weyher and Richemund Company to be 12·5 lbs. of water per lb. of fuel; at the power station of the electric tramways of Los Angelos it was 12·89 lbs.; and in other experiments, with Borneo petroleum, 758 grammes of oil produced the same results per H.P. hour as 1,030 grammes of Newcastle coal. At the last Exhibition in Chicago the steam boilers, working at about 125 lbs. per square inch pressure of steam, gave with mineral oil fuel an evaporation of 14·25 lbs. of water per lb. of combustible as against 7 lbs. per lb. of coal. The theoretical evaporative power of carbon burning to carbon dioxide is 15 lbs. of water at boiling-point under atmospheric pressure.

In steamships it is necessary to use heavy oils igniting at 121° to 149° C. in order to guard against the risk of fire, these oils being quite safe even if a bar of red-hot iron be plunged into them. Experiments made by the French Government on the use of petroleum in torpedo-boats proved that it is too dangerous for use in such vessels.

Tweddle made experiments by firing cannon-balls and shells into a pile of casks containing benzene, with the result that the flame from the exploding shell frequently set fire to the benzene vapour. Practically the same effects were produced with kerosene and crude petroleum, but with oil igniting at 115° C. no flame was produced even under much more severe tests. If the oil employed has a sufficiently high point of ignition it offers greater security from fire than coal and much more than powdered fuel in bulk, both under the conditions of warfare and under ordinary conditions in which spontaneous combustion sometimes occurs.

The handling and storage of liquid fuel are also a much more easy matter than is the case with coal; the necessary appliances are fewer and more simple, and the minimum of labour is all that is required. There are also other minor advantages, not the least of which is the saving of space on board ship for storage of fuel.

In furnaces used in the industrial arts some of its advantages may be realised, where a high temperature and a pure flame are desired and when the price of coal is high. The author gives some illustrations of such furnaces, and, in particular, of one designed by Tweddle for the combustion of benzene.

F. J. R.

GAS AND OIL ENGINES.

1548. *Electrical Ignition for Gas Engines.* **P. P. Nungesser.** (Elect. World and Engineer, 35. pp. 510–511, April 7, 1900.)—Reliable electric *igniters*, that combine durability with simplicity of construction, have met with the greatest success in the hands of the average operator. Electrical

igniting devices consist of two classes: primary and secondary. Primary igniters, by far the most largely used, are made in three forms: (1) The striking or "make and break" contact employs a movable point, operated by mechanism *outside* the cylinder to strike the stationary point, and can be adjusted to produce ignition at that part of the stroke which gives the highest efficiency with the given combustible mixture. (2) The rotary or wipe spark igniter, which has great wear in the sliding contacts and requires frequent attention to keep it in order. This form gives, with the same consumption of battery power, a much larger spark than the striking or make and break igniter. (3) The make and break *inside* igniter, which has the movable part attached to the piston, and separated from the insulated stationary rod by the forward motion of the piston, thereby igniting the mixture.

In the second class, known as jump spark electrical igniters, there is an insulated plug through which pass the wires from an induction or secondary coil to points in the combustion chamber, $\frac{1}{8}$ to $\frac{5}{16}$ inch apart. The spark passes through this air space when the primary or battery circuit is closed.

Experience, on automobile and yacht engines, has shown that a battery having $4\frac{1}{2}$ to 6 volts is required with low internal resistance to give 8 to 16 amperes. Waste of current is prevented by having the spark coils of suitable impedance, which may double the life of the battery. Instead of the old style long coils, a primary coil best suited for high speed engines, such as used on automobiles, should not exceed 6 inches in length overall, made of annealed Swedish iron, reannealed after cutting, in order to be magnetised and demagnetised rapidly. This shortens the time the circuit has to remain closed, and gives economy in battery power.

Spark coils must be thoroughly waterproof for good insulation. A dry battery is sometimes used for starting an engine where a dynamo or magneto-generator, driven by the engine, gives ignition until the speed is reduced. The high speed necessary for these generators produces considerable wear of moving parts.

The writer considers a good portable closed circuit battery, perfectly sealed or water-tight, without paraffin oil, is not only more economical than the dry battery and dynamo combination, but it requires less care in the rough usage of engines on carriages and boats. W. R.

AUTOMOBILISM.

1549. *Renaux Motor Tricycle.* (Automotor Journal, 4. pp. 379–381, May, 1900.)—A full description, with illustrations from La France Automobile, of a motor tricycle in which the differential gearing is incorporated into the motor itself and in which the motor-shaft is practically in line with the transmission gear and with the driving-wheel axles. The motor is arranged to form a portion of the framework of the cycle and it is fitted with roller-bearings throughout (including the crank-pin). The differential gear is formed by a planet pinion-wheel, which is mounted in bearings in the crank-pin and which meshes with (and drives) pinion wheels upon the two driving axles. The crank-pin is secured to two fly-wheels which run independently from, and concentrically about, the driving axles. Rack (internal) and pinion transmission gearing are used for reducing the speed of the driving-wheels, relatively to the motor-speed. The motor has a single cylinder, 90 mm. bore × 90 mm. stroke, and develops about $3\frac{3}{4}$ H.P. at 1,400 r.p.m. The weight of the tricycle is about 140 kg. A Longuemare carburettor is used and a high tension, variably timed, ignition device is employed. A. G. N.

1550. *Stanley Steam Carriage.* (Automotor Journal, 4. pp. 387–390, May, 1900.)—A description of the lighter type of American steam carriages. The boiler is of copper with steel ends and is 18 inches high; 298 $\frac{7}{16}$-inch tubes, $\frac{1}{16}$-inch thick, are expanded into the boiler ends. Piano steel wire is wound round the copper boiler and lagging is provided outside this wire. The furnace consists of 2,500 jets and is fed with petroleum at a pressure of about 35 lbs. per square inch; the petroleum feed is controlled by an automatic valve actuated by the steam pressure and is heated, before reaching the burners, by being passed through a pipe which is carried through two of the boiler-tubes. The working pressure is 160 lbs. per square inch; at this pressure the steam cuts off the fuel supply to the furnace. The engine is light, is fitted with ball-bearings throughout, has two double acting cylinders ($2\frac{1}{2}$-inch bore by $3\frac{1}{2}$-inch stroke) and develops about 4 H.P. The transmission gear consists of a single ($\frac{3}{8}$-inch) chain drive, from the engine shaft to the differential gear on the "live" back axle, and provides for a car-speed of 10 miles per hour when the engine is running at 400 r.p.m. Water is fed to the boiler by a force-pump, driven by the engine. The driver regulates the water-feed by a bye-pass on the pump, in accordance with the showing of a water-gauge. The car weighs about $4\frac{1}{2}$ cwt. Drawings are given of a larger vehicle, of the same type, which was previously described in Abstract No. 563 (1900). A. G. N.

REFERENCES.

1551. *Feed-water Heaters.* (Amer. Electn. 12. pp. 236–238, May, 1900.)—A notice of some forms of feed-water heaters constructed in America, of the U-tube, coil and straight tube kinds, some having the steam and some the water inside the tubes. This article is in continuation of others which have appeared in the January and February issues of the same journal, and contains good descriptions and illustrations of the Stilwell, Hardwick, Otis, Devries-Berryman, Kelley-Berryman, Robertson, American, Goubert, and Wheeler heaters. F. J. R.

1552. *Parsons Steam Turbine.* (Amer. Electn. 12. pp. 124–127, March, 1900. Also Mech. Eng. 5. pp. 409–411, March 24, 1900.)—An article, illustrated by drawings and process blocks, describing this turbine. Steam consumption curves for a 500-H.P. set are also given.

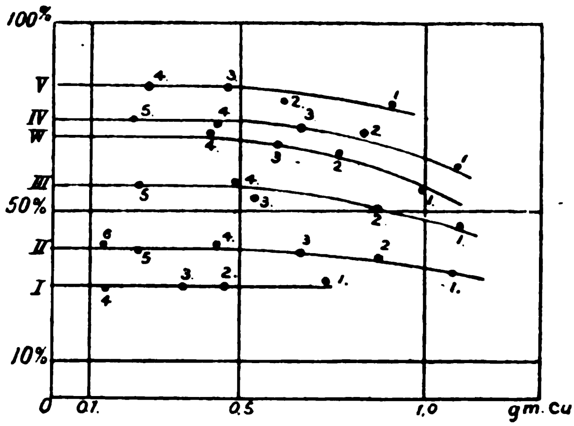
GENERAL ELECTRICAL ENGINEERING.

1553. *Estimating the True Surface of Accumulator Plates.* **K. Norden.** (Zeitschr. Elektrochem. 6. pp. 397–403, Feb. 1, 1900.)—Since Planté employed his first accumulators of rolled-up lead sheets, instead of flat plates, the direction in which the perfection of the accumulator, as regards its capacity, could be approached has been clearly indicated. This lies in increasing the ratio of the true surface of the plate to its apparent surface—the "surface-development," as it has been called by A. Wilke. The apparent surface is, of course, obtained by simply measuring the depth and breadth of the plates. The problem is to ascertain the true surface which at the same time with any given current enables the true current density to be obtained. There is no difficulty in regard to ribbed plates of the Tudor or Majert type. The true surface can be directly measured, and is from eight to nine times the apparent surface in the former case and about fourteen times the apparent surface in the latter. In the case of pasted plates no such method can be employed, and the present method has been devised to overcome the difficulties of the problem in this case. The main idea of the process is to employ some substance as an addition to the electrolyte, which, as a secondary effect of the current passing, is acted on or decomposed. After reviewing the various reagents that might be employed for the purpose, the author sums up in favour of oxalic acid, which accordingly was the substance adopted. Owing to the high resistance of the oxalic acid, the current may be regarded as entirely passing through the sulphuric acid which is added to the bath to prevent the necessity of employing too high a potential. A portion of the oxygen developed at the anode accordingly oxidises the oxalic acid to CO and CO_2, the extent of this action being proportional to the current density. Instead of analysing the gases given off, Oettel (Zeitschr. f. Elektrochem. 1. p. 90) has estimated the oxalic acid remaining in the electrolyte by titration with permanganate—the total current used being estimated by the insertion of a copper voltameter in the circuit. The assertion previously made by Avery and B. Dales (Ber. d. d. Chem. Gesell. 32. p. 2233), that during the electrolysis of oxalic acid glykolic acid is produced by reduction at the kathode, was found to be only true under certain circumstances. Previous researches have established that the electrolysis of oxalic acid, in addition to being dependent on the surface of the anode and the current, increases with the temperature and the degree of concentration. The process, as Oettel has pointed out, must therefore not be continued too long. To work to a particular degree of concentration, owing to the difficulty and complication in so doing, is not recommended. The experiments were performed on an incandescent lamp circuit of 110 volts, a delicate adjustable resistance being employed to keep the current absolutely constant. In the experimental cell there was employed as electrolyte 200 c.c. of $N/4$ oxalic acid solution, to which was added sulphuric acid to the extent of 50 gm. per litre. As the temperature had to be kept constant the cell was immersed in a basin of water, by which means the temperature was throughout kept very nearly at 18° C. The following table gives the results of one series of experiments, using

200 c.c. of oxalic acid (0·2500 N = 8·150 gm.), and anode surface of 18 sq. cm. :—

Experiment.	Duration of Experiment—Min.	Current Amperes.	E.M.F. of Bath Volts.	Increment of Copper Voltameter—Grammes	Oxalic Acid Oxidised—Grammes.	Gms. Cu. Equivalent to Acid Oxidised.	Decomposition Value—per cent.	Decomposition Value Obtained from Curve for $t=0$—per cent.	Mean Anode Current Density for the Series.
1	60	2·05	4·0	2·4276	1·435	0·725	29·9	28·5	11·43
2	40	2·04	4·22	1·6070	0·920	0·464	28·9		
3	30	2·06	4·0–4·13	1·2210	0·695	0·351	28·7		
4	12	2·08	3·87–3·76	0·4946	0·272	0·137	27·8		

In this table t is the duration of the experiment. In order to find the percentage decomposition (copper equivalent to acid oxidised, copper equivalent to total coulombs) at the moment of closing the circuit, *i.e.*, when $t=0$, the author plots the percentage decomposition against the equivalent of copper for each series (as shown in the figure), and produces the curves so obtained back to the axis.



To obtain from the above table the comparative results a series of comparable experiments with an anode of *known* surface were necessary. These were carried out under conditions similar to those under which the above table was obtained with a lead plate of 0·333 sq. dcm., folded up to resemble a ribbed plate of 0·222 sq. dcm. apparent surface, and the results give rise to curve W in the diagram.

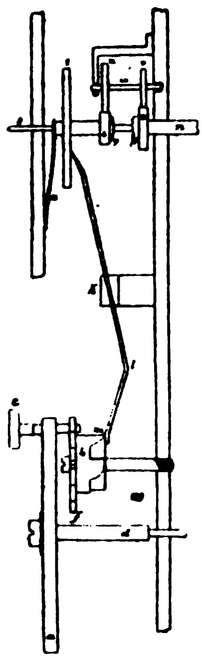
Estimates made from the last series of experiments of the experimental error involved in the method show that it does not exceed 6·6 per cent.

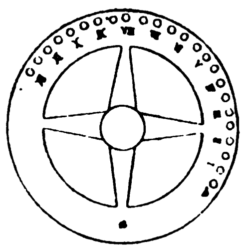
R. N. L.

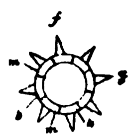
1554. *Sliding-scale Electricity Meters.* **Kusminsky.** (Zeitschr. Elektrochn., Wien, 18. pp. 158–159; Discussion, pp. 159–160, March 25, 1900.)—

The first of these meters discussed is that of L. Zahn. This is of the Aron-type, and has a mechanical clutch controlled by a clock, which effects the throwing into and out of gear of mechanism for varying the number of revolutions made by the counting train.

On the meter case is mounted a second case, which contains an independent clockwork movement which, in twenty-four hours, rotates a wheel *a* through one revolution. This wheel is provided around one-half with hour marks XII to I, and has holes *b* to receive pins *c*. Near this wheel is freely mounted a wheel, *f*, having arms, *g*, and rigidly secured to a cam-wheel having four projections, *m*, and four depressions, *h*. If a pin be inserted into one of the holes, *b*, in the rotation of the wheel, *a*, this pin strikes against an arm, *g*, of the wheel, *f*, and turns it through one division, together with the cam-wheel, which causes a double-armed lever, *l*, to oscillate and throw over a clutch,







whereby a different counting train is thrown into action. By placing the pin, *c*, in one or other of the holes, the time at which this change takes place can be varied as desired.

An instrument is constructed by the General Electric Company, having two meters, of which one runs continuously and registers the amount to be paid, whilst the other is only thrown into gear at predetermined times and registers the excess charge.

The Union-Elektricitäts-Gesellschaft has a meter in which the brake-magnet exerts a greater retarding force during the day than in the evening.

In the discussion the fact was referred to that the movable coil of a Deprez-d'Arsonval galvanometer will act in a similar manner to a condenser if the moment of inertia of the movable coil and the periodicity of the alternate-current are very low and the strength of the field very high.

C. K. F.

1555. *Rimington Maximum Demand Indicator.* (Electrician, 44. pp. 921–922, April 20, 1900.)—This indicator is designed to be applied to electrolytic meters of the Bastian type [see The Electrician, 41. pp. 104, 112, 138] and consists of a U-tube, the first limb of which is connected by a flexible tube to a glass tube sealed into the top of the electrolytic meter in such a way that the evolved gases are carried off through this tube. The second limb is provided at its upper end with a porous plug which prevents violent movement of the liquid contained in the lower part of the U-tube. Near the upper end of the first limb is another porous plug. The rate at which the gases are evolved (varying as the current) determines the pressure of the gas in this part of the tube, and all the liquid raised thereby into the second limb overflows into a vertical tube flexibly connected thereto. The maximum current passed through the meter, therefore, is indicated by the height of the liquid in the vertical tube above mentioned. The time lag in the working of the indicator can be controlled by the plug at the top of the second limb.
C. K. F.

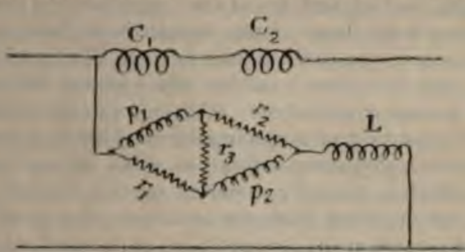
1556. *Fault-Detector for High-Pressure Concentric Cables.* **F. Probst.** (Zeitschr. Elektrotechn., Wien, 18. pp. 161–165, April 1, 1900.)—A pair of small section insulated wires are laid on with the outside copper conductor of a single-phase concentric cable. These wires are connected, in a special manner described, to bell signals at the central station, and in case of a short circuit the attendant at once knows its position. E. K. S.

1557. *Enclosed Fuses.* **J. Sachs.** (Amer. Inst. Elect. Engin., Trans. 17. pp. 85–116, Feb., 1900.)—A fuse should have a definite maximum continuous running current capacity, and blow for a definite overload whether gradually or quickly reached. The fuse advocated has a zinc or aluminium link of wire or strip in a powder containing borax, which will dissolve the oxides, and prevent the formation of a tube full of molten wire. Copper wire is not desirable, because when disrupted it yields a conducting vapour. On short-circuiting a fuse with long break an objectionable arc is prevented by the sudden disrupting of the fuse, but with slow overloading this may not be the case. An inductance in series with a large fuse diminishes the maximum rush of current but increases the potential of break across the fuse terminals.
M. O'G.

1558. *Electrical Absorption Dynamometer.* **A. Grau.** (Elektrotechn. Zeitschr. 21. pp. 265–267, April 5, 1900.)—The determination of the brake-power of a motor by means of any ordinary form of mechanical absorption dynamometer does not admit—especially in the case of small motors—of any high degree of accuracy. The friction between the brake and pulley is liable to undergo constant changes, and seriously interferes with the accuracy of the measurement. The author describes an electrical dynamometer which is capable of giving excellent results. It consists of a circular disc of copper mounted on the shaft of the motor, and placed between the poles of an electromagnet attached to a long lever which is mounted on knife-edges and carries a sliding-weight. The principle of the arrangement is identical with that used in several well-known supply meters for providing the resisting torque. By sliding the counter-weight along the lever, the pull on the magnet due to eddy-currents in the brake disc may be balanced. This pull may be maintained absolutely constant by means of a continuously variable resistance in the exciting circuit of the electromagnet. The author states

that in the instrument used by himself a displacement of the sliding-weight of less than 1 mm. was sufficient to upset the balance. The results of some brake tests on a 1 H.P. motor are given, and show in a striking manner the high degree of accuracy attainable by means of this method. A. H.

1559. *Alternate Current Meters with Rotary Field.* (Elekt. Runds. 17. pp. 131–132, April 1, 1900.)—In meters of this description two adjustments are necessary: first, a phase-adjustment for the shunt circuit, whereby the field of this circuit is brought exactly into quadrature with the impressed P.D.; and secondly, an adjustment for varying the field intensity so as to enable the instrument to be made direct reading. Altering one of these adjustments generally upsets the other, so that the final adjustment can only be obtained satisfactorily after a good deal of trouble. In order to avoid this difficulty



Siemens and Halske have recently introduced the method of connection shown in the accompanying diagram, in which C_1 and C_2 are the main or current coils, and p_1, p_2 the pressure coils, producing a field which is in quadrature with the main field. The phase-adjustment is obtained by varying the non-inductive resistance r_3, and the intensity-adjustment by varying simultaneously the two equal resistances r_1 and r_2; L being a reactance-coil which is joined in series with the Wheatstone-bridge arrangement of the shunt circuit. A. H.

1560. *Aluminium Electrical Conductors.* **F. C. Perkins.** (West. Electn. 26. pp. 146–147, March 10, 1900.)—This paper deals with the possibilities of aluminium for use in electrical work. Figures relating to the physical and mechanical properties of aluminium are given, from which it would appear that for a given conductivity the weight of an aluminium conductor may be taken as 50 per cent. of that of copper. A description is given of the plant which has recently been erected by the Pittsburg Reduction Company and the Niagara Falls Power and Manufacturing Company to cope with the expected demand for aluminium in electrical construction, and which includes four 1,000-H.P. continuous current Westinghouse generators and turbines, and the erection of two new turbines by the Niagara Falls Company.

Instances are cited of the use in practical work of aluminium conductors in railway feeders, power transmission lines, and electric elevated railroads, and the relative merits of copper and aluminium for conductors generally are discussed. The paper concludes with some statements respecting the electric properties of the two metals when used in electric circuits. E. C. S.

1561. *Electrical Time Service.* **F. Hope-Jones.** (Inst. Elect. Engin., Journ. 29. pp. 119–138; Discussion, pp. 141–153, Jan.; and pp. 286–288, March, 1900.)—The author gives a short *résumé* of the various types of electric clocks

which have been made, and finally sums up in favour of a system in which a controlling or master-clock sends out frequent impulses into the line to directly propel the hands of large numbers of indicator dials. He then proceeds to describe a system patented by himself and G. B. Bowell, which comprises special forms of controlling clock and indicator dial. The controlling clock consists of a clockwork train, which is controlled by an escapement, and in which the main-spring is replaced by a ratchet-wheel acted upon by a pawl on a weighted lever. This weighted lever has an arm forming a bridge-piece which, as the weighted lever approaches its lowest position, short-circuits two contacts mounted on a spring-controlled pivoted lever, forming the armature of an electromagnet in the line circuit. The armature lever is then attracted, the weight raised, and the circuit again broken. By these means the entire energy required for keeping the pendulum swinging is mechanically transmitted through the contact surfaces at each operation, so that these contact-surfaces are always kept clean. Some hundreds of these instruments have been in use for several years without any failure. The actuating mechanism of the indicator dial comprises a ratchet-wheel having 120 rectangular teeth, mounted on the minute-wheel arbor. With this ratchet-wheel there engages a retaining pawl consisting of a rectangular steel block at the extremity of a long pivoted arm arranged along a chord of about 90° on the ratchet-wheel. The propulsion-pawl is pivotally mounted on one arm of a double-armed lever, the other arm of which bears the armature; this pawl acts at an angle of 135° to the radius, and, at the forward limit of its travel, where it is normally held by a flat spring, it abuts against one stop, and at the backward limit of its travel it abuts against a second stop. A modified form is shown applied to a turret clock and actuated through a relay. The paper comprises a bibliography of the subject.

In the discussion **A. J. Lund** advocated the use of synchronised clocks on the ground that, if the line broke down, the clocks would still go on unsynchronised.

C. Puttkammer described the Normal Time Company's system, wherein the clocks are successively regulated from a central timepiece, and are wound up electrically, either by a strong current (Aron system), or by a weak current (Normal Time system). There is a registering contrivance on the central time-piece whereby a mark is registered on a running strip of paper so as to enable the deviation of each clock to be determined.

Hope-Jones, in his reply, stated that, in the controlling clock, there was a maintaining spring connecting the ratchet-disc and the train so that the going pressure is never off the escapement. C. K. F.

1562. *Electric Annealing of Armour-plate.* **C. J. Dougherty.** (Eng. Club Phil., Proc. 17. pp. 12–22; Discussion, pp. 22–23, Feb., 1900.)—The author begins by explaining the disadvantages of having to bore the holes in armour-plates before hardening them by the Harvey or Krupp processes, and mentions sundry abortive attempts which have been made to obviate the difficulty. He then proceeds to explain the method devised by the Thomson Electric Welding Company, of Lynn, Mass., and the apparatus utilised for the purpose of locally softening the steel by means of the intense heat of a very heavy current. The current is generated at 300 volts, and the maximum employed is 100 amperes. It is transformed down to from 2·5 to 2·8 volts, and at the maximum 10,000 amperes are passed. The current is introduced by special water-cooled copper contacts and a current density of as much as 40,000 amperes per square inch is employed where these touch the surface of

the plate, but so effective is the water-cooling that the leads do not suffer at all. The current has to be turned on gradually by means of a resistance, and must not be switched off suddenly or the softening is not effected. The operation takes from fifteen to twenty minutes. Illustrations and diagrams are given. J. L. F. V.

1563. *Electricity applied to Agriculture.* **P. Renaud.** (Électricien, 19. pp. 259–264, April 28; 281–285, May 5; 311–316, May 19; 326–332, May 26, 1900. Lecture delivered before the Société Industrielle de l'Est.)—The author insists on the absolute necessity of mechanical power for certain agricultural operations, and states that the direct application of steam power is too expensive and cumbersome. To break up 2½ acres of land to a depth of 26 inches (for vine-culture) by steam power costs £15, while by electric power the cost, inclusive of capital charges, amounts to only £7·2; the portable steam machinery weighs twelve tons, the electrical machinery four to five tons. After briefly outlining the history of the subject, and the different methods of working that are available, and referring to certain apparatus of which figures are given, the author describes the systems of F. Prat and the Eckert firm, in which the plough is hauled by an electric windlass, working in one direction, and returning idle. In the Brutschke system the plough works in both directions, the windlass being reversed at the completion of each furrow; the bight of the cable is carried round a pulley mounted on a four-wheeled carriage, the wheels of which are flanged to grip the soil, while an anchor with four blades provides additional resistance to the pull of the cable. When the plough is travelling towards the windlass, the pulley, rotated by the slack cable, is geared to a mechanism which raises the anchor and moves the carriage forward a set distance; the anchor is driven into the ground again by the reversal of the motion of the pulley when the plough starts on the return journey. At Ben-Sala, in Algeria, where the ground has to be worked between full-grown vines, an electric windlass is used at each end of the field, and the plough, instead of being double-ended, is turned round at the end of each furrow.

The Dollberg, Förster, and Siemens systems are critically described, with illustrations; references are given to more detailed descriptions. In the Förster system, with two windlasses, half the copper in the electrical circuit is saved by running a single cable to each windlass and utilising the steel haulage rope to complete the circuit. A table of results is given, from which it is seen that the best performance was obtained from the Siemens system: the efficiency was 66 per cent., with 16·5 H.P. at the ploughshares. The surface worked over in one hour without stoppage, ploughing 1 foot deep, was about one acre; as the stops aggregated 20 per cent. of the whole time, the net area worked per hour was about three-quarters of an acre. The applications of electricity to the transport of materials, threshing-machines, forage-compressors, chaffcutters, and sheep-shearing, are briefly touched upon, and the paper is concluded with a *résumé* of the many advantages derived from the use of electricity in agriculture. A. H. A.

1564. *Electric Riveting Machinery.* **F. v. Kodolitsch.** (Cassier, 18. pp. 71–74, May, 1900.)—The author has been experimenting on electric riveting machines, and has succeeded in bringing out two types capable of superseding hydraulic and pneumatic systems. He demonstrates that the initial capital outlay is far less for an electric system than for either an hydraulic or pneumatic installation, while the cost of up-keep is less. As

regards the quality of work done, there is no difference, but the output of the electric system is considerably superior. The machine described by the author has closed, for weeks and weeks, 1,500 rivets per day of ten hours, requiring the attendance of only three men and a boy. In the machine there is one heavy disc which is always rotating. This disc may at any moment be made an electromagnetic coupling, by which a second disc keyed on to a screw-spindle may be rotated. The screw-spindle moves a large nut at the end of a toggle-joint, which raises and lowers the die for making the rivet-head. There is an automatic cut-out arrangement by means of which the two discs may be disconnected before the end of the travel of the nut. The energy of the second disc is then utilised to finish the rivet. The screw-spindle is four-threaded, the pressure of fifty tons put on the rivet-head is ample to make the machine reverse automatically; that is, after the rivet-head is closed the nut returns again to its original position to be ready for the next stroke. It is indifferent whether two, three, or four thicknesses of the plate be put between the dies, and no adjustment is necessary for different thicknesses. A. S.

1565. *Epicycloidal Method of Loading Moving Platforms.* (Street Rly. Journ. 16. p. 326, April, 1900. From the Zeitschrift des Vereins Deutscher Eisenbahnverwaltungen.)—This is an illustrated description of an arrangement devised by Vietor, whereby passengers can be conveyed automatically to a continuously moving platform, or a moving railway train, without the necessity of stepping from a stationary to a quickly moving part. The principle of the arrangement is as follows: The fixed platform is a circular disc; outside and concentric with the platform, but some distance away from it, is the circular track of the moving platform or railway train. Between the fixed disc and the moving track outside are smaller discs, the diameters of which are equal to the space between the fixed disc and the moving ring. These small discs practically roll along the circumference of the fixed disc, receiving their motion from the moving outer ring, and serve as the actual conveyers of the passengers. Some particulars of the construction and sizes are given. The advantages claimed by the inventor are: Low cost of construction and operation; small weight of rolling stock and equal division of load; no waiting for trains, or stoppage of them, at stations; absence of signals; a saving of rails and rolling stock on account of the uniformity of traffic; absence of noise, and convenience to passengers. It is proposed to show the method in operation at the Paris Exhibition. E. D. P.

REFERENCES.

1566. *Edinburgh Cable Tramways.* (Tram. Rly. World, 9. pp. 89–108, March, 1900.)—A very complete description of this system of cable tramways, with drawings showing in detail the construction of the track, conduit, &c., and photographs of machinery in the power houses.

1567. *High-Tension Switches, &c.* **Vedovelli.** (Soc. Int. Élect., Bull. 17. pp. 107–120, Feb., 1900.)—Description of high-tension switches, oil-fuses, horned lightning arresters, &c.

1568. *Electric Fans.* (Elect. Rev. N.Y. 36. pp. 159–168, Feb. 14, and 185–188, Feb. 21, 1900.)—Articles containing about fifty photographs of different types and arrangements of fans and motors as made in America.

GENERATORS, MOTORS, AND TRANSFORMERS.

1569. *Siemens and Halske Three-phase Generating Set at the Paris Exhibition.* (Elektrotechn. Zeitschr. 21. pp. 344–346, May 3, 1900.)—The machine is direct-coupled to a Borsig vertical engine, and the full load output is 2,000 kw. at 2,200 volts, 50 periods at 83·5 r.p.m. The poles are laminated; the field-magnet system forms the flywheel of the engine, and is mounted on a separate shaft with two bearings. The field copper is wound on edge, and its cross-section is 4 × 23 mm. Cross-sections are given, showing the construction of the armature and the cast-iron ring, &c. The armature conductors have a cross-section of 7 × 44 mm., and are arranged in 648 slots, each 13 × 55 mm., lined with micanite. The exciter is mounted direct on the alternator shaft; it is an eight-pole machine, and gives 45 kw. at 210 volts. E. K. S.

1570. *Lahmeyer Combined Three-phase and Continuous Current Set at the Paris Exhibition.* (Elektrotechn. Zeitschr. 21. p. 366 and pp. 367–368, May 10, 1900.)—The two machines are mounted at each end of a Nürnberg compound vertical engine and run at 94 r.p.m. The three-phase machine has an output of 1,000 kw. at 5,000 volts and 50 periods, the number of poles being 64, mounted on a double-armed flywheel. The continuous-current machine has twelve poles, and gives 350 kw. at 550 volts. Each machine is mounted on a separate shaft with outer bearings, and the rotating parts form the flywheel of the engine. The alternator has its own exciter, coupled direct. Six drawings are given, showing the construction of the machines. E. K. S.

1571. *Maximum Economy in Dynamo Construction.* **Mélotte.** (Assoc. Ing. Él. Liège, Bull. 11. pp. 85–109, April 20, 1900.)—The author assumes a fixed total flux, and output and efficiency, and then shows how the cost varies as the induction in the different parts of the magnetic circuit is varied. Curves are given, showing the cost of copper and iron in each part, and also the total. The cost of labour and general charges are allowed for in the price of materials. The author assumes as sufficiently true for the purpose that the weight of copper on the magnets varies as the square of the ampere turns, and inversely as the induction, and the weight of iron varies as the induction. He shows that if the relative price of copper and iron varies, the point of minimum total cost does not vary very much, and that the total flux may be varied between wide limits without affecting the point of minimum cost to any great extent. R. B. R.

1572. *Rheostatic, Double Commutator and Multivoltage Regulation of Motors.* **A. D. Adams.** (Amer. Electn. 12. pp. 208–211, May, 1900.)—Where only two speeds are required, the motor armature may be double-wound, the two windings being similar and used in series or parallel. For three speeds the two windings are unlike, and used either one singly, or the two in series. If three generators are used, giving respectively 40, 80, and 100 volts, arranged on a four-wire system, six different pressures of supply can be obtained.

R. B. R.

1573. *Regulation of Motors by Varying Impressed and Countei E.M.F.'s.* **L. B. Mather.** (Amer. Electn. 12. pp. 211–213, May, 1900.)—The author describes five different systems. The Leonard system, in which an auxiliary motor-dynamo supplies current to the industrial motor. The speed control is good, but the cost is more than three times that of an ordinary motor. In another system, which is practically a modification of Leonard's, the same motor-dynamo is used, but the dynamo armature is connected to the supply circuit in series with the industrial motor armature, and opposing the supply E.M.F. In this case the motor-dynamo need not be quite so large. Equivalent results can be obtained by a motor three or four times the ordinary size arranged for regulation by varying the strength of its field magnet. The motor is compound wound, the main being in four coils which can be coupled in eight different ways by a controller. Another method is a six-wire system with five equalising dynamos or motors, with their shafts rigidly coupled, connected across the outer wires. For a 250-volt generator these equalising machines would be arranged in the following order : 50 volts, 25, 100, 50, 25. In this way any voltage may be obtained from 25 to 250, advancing by steps of 25 volts. All the equalising machines have the same output in watts, so that their current-carrying capacities differ. Some of the motors may be arranged to start on one of the 25-volt circuits, and some on the other, giving a better distribution of power on the circuit wires than there would be if there were no duplicate voltages. In the fifth system the equalising machines are replaced by 125 cells. In this system, of course, a much finer gradation of speed may be obtained by the use of a sufficient number of circuit wires. R. B. R.

1574. *Regulation of Motors Driving Printing Presses.* **T. a'Becket.** (Amer. Electn. 12. pp. 213–214, May, 1900.)—In driving printing presses the motor is usually required to run at a fixed speed, but occasionally it must run for a short period at a very slow speed during the "making ready" of the formes, and it must start without shock, under load. A special form of multi-contact resistance switch is useful for this. The first step puts one coil of resistance in parallel with the armature of a shunt motor, and the rest in series with the armature ; the next steps reduce the resistance in series, and increase it in parallel, till it is all in parallel, and then cut it out altogether. In another method the motor is compound, with four shunt coils in parallel. The first step of the switch puts in the series coil, and the four shunt coils in parallel. The succeeding steps first cut out the series coil, and then three of the shunt coils one by one. A combination of these two methods would give an ideal method of speed control for a printing press, when it is desirable to run at any one of several regular speeds not far apart, depending on the character of the printing to be done. R. B. R.

1575. *Controlling Frequency of Inverted Rotaries.* (Elect. World and Engineer, 35. pp. 507–509, April 7, 1900.)—By an inverted rotary converter is meant one used for transforming continuous into polyphase currents. Cases in which such inverted converters are used occur when it is more economical to supply a limited alternating-current service from a large continuous-current central station than to put down a special alternating-current plant for the purpose. When a rotary converter is used in the ordinary way, absorbing power from alternating-current mains and delivering continuous current, its speed is fixed by the frequency of the alternating current, the rotation being a synchronous one. But the speed of an inverted rotary is no longer

controlled in this way: it is now running as a shunt-wound motor, and its speed will depend on the field intensity. If the currents on the polyphase side lag behind the E.M.F., the field may be greatly weakened, and the speed may rise to a dangerous extent. Similarly, a drop of speed may result from leading currents due to capacity in the mains or some other cause. In order to prevent such fluctuations in speed, and avoid the risk of speeds exceeding the safe limit, a very ingenious arrangement has been devised by B. G. Lamme, and has been applied in several instances by the Westinghouse Company. It consists in separately exciting the converters by means of a shunt-wound machine, whose armature is mounted on the converter shaft, and which is normally worked well below the bend in the magnetisation curve, so as to be extremely sensitive to very small changes in the speed. Any tendency towards an increase of speed is immediately checked by a very rapid rise in the P.D. of the exciter and consequent increase in the exciting current of the converter. A similar action in the opposite direction takes place when the speed tends to decrease. The arrangement has been found to give thoroughly satisfactory results. A. H.

1576. *Rotary Converters.* **H. S. Meyer.** (Elektrotechn. Zeitschr. 21. pp. 267–269, April 5, 1900. Translated in El. Eng. 25. pp. 618–620, May 4, 1900.) —The author briefly discusses the uses of rotary converters, and considers the various methods of excitation. The shunt winding is suitable where special arrangements are provided for regulating the P.D. at the ends of the various feeders on the continuous-current side. More commonly, however, the compound winding is used, by means of which an increase of the terminal P.D. may be obtained with an increase of load. This effect is brought about by the varying phase-displacement of the current relatively to the P.D. With light loads the current should be a lagging one, and with heavy loads a leading one. Between the converter terminals and the three-phase supply-mains are inserted suitable choking coils, by the action of which a leading current causes a rise of P.D. across the converter terminals, while a lagging current causes a fall of P.D. Frequently the line itself has a sufficient amount of inductance to provide the necessary regulation, and then the choking coils may be dispensed with. It is to be noted that an increase in the excitation *per se* is unable to cause any change in the P.D., for the ratio of the continuous to the alternating P.D. is perfectly definite, and, though slightly variable with the load, is independent of the excitation. A third method of excitation consists in omitting the field winding entirely, so that the excitation is furnished by the armature current. On account of the extremely heavy wattless currents, and consequent low power-factor, this form of converter can hardly be expected to find any application in practice, except in cases where cheapness of construction is of paramount importance. The author finally deals with *inverted* rotaries (see preceding Abstract). In order to prevent racing, these machines should be over-excited and furnished with centrifugal regulators for cutting off the supply of current when the speed exceeds a certain limit; or the device described in the preceding Abstract may be used. A. H.

REFERENCE.

1577. *Double-Wound Armatures.* **A. D. Adams.** (Amer. Electn. 12. pp. 121–122, March, 1900.)—The author describes different kinds of double-wound armatures, and discusses their various uses. A. H. A.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

1578. *Long-distance Transmission.* **L. Bell.** (Elect. Rev. N.Y. 36. p. 227, March 7, 1900.)—The limit in power transmission is, broadly speaking, indeterminate, for the distance practicable is a function of the price of fuel, and the voltage is in the main a function of climate. The necessary combinations for a successful trial are—a good market, a very high price of coal, and a climate dry enough to make insulation easy. Mexico or some portion of South America seems to be the place where we must look for pioneering work in this direction. The author points out that the present upper limit of high voltage seems to be set by the tendency of the air to fail as a dielectric. So far as the transformers are concerned the splendid insulating properties of oil have not been put seriously to the test by even the highest experimental voltages. In a dry climate one could safely go to 50,000 volts under existing conditions, and the author then imagines a typical case of the transmission from water-power of 1,000 H.P. over a distance of 200 miles at a voltage of 50,000 and a loss of 10 per cent. After computing the cost of copper, poles, plant, &c., he finds that a sale of 1,000 H.P. at 100 dollars per H.P. year would pay interest, and also provide a liberal sinking fund. This price is less than the cost of producing power in units of moderate capacity even in places where coal is no more than five or six dollars per ton. With coal at a higher price, electrical power transmitted even to so great a distance could cut under the cost of steam power and secure a paying market. W. G. R.

1579. *Importance of Wave-form in Three-phase Working.* **O. S. Bragstad.** (Elektrotechn. Zeitschr. 21. pp. 252–254, March 29, 1900.)—This is an important paper dealing with the effect of harmonics in three-phase working. If i_1, i_2, and i_3 stand for the instantaneous values of the current in the three-line conductors, we may write—

$$i_1 = \sum_{n=1}^{n=\infty} (A_1 \sin npt + B_1 \cos npt),$$

$$i_2 = \sum_{n=1}^{n=\infty} (A_2 \sin n\left(pt + \frac{2\pi}{3}\right) + B_2 \cos n\left(pt + \frac{2\pi}{3}\right)\Big\}$$

$$i_3 = \sum_{n=1}^{n=\infty} \Big\{ A_3 \sin n\left(pt + \frac{4\pi}{3}\right) + B_3 \cos n\left(pt + \frac{4\pi}{3}\right)\Big\}$$

On account of symmetry, $A_1 = A_2 = A_3$, and $B_1 = B_2 = B_3$. Further, we must always have $i_1 + i_2 + i_3 = 0$. From these conditions it follows that n must satisfy the equation $\cos n \frac{2\pi}{3} = -\frac{1}{2}$, and that consequently the possible values for n are 1, 2, 4, 5, 7, 8, 10, 11. . . . *In other words, in a three-phase system of currents, all harmonics whose frequencies are multiples of the fundamental frequency divisible by three are excluded.* Next, if there is symmetry of positive and negative half-waves, all the even harmonics are excluded. In this case the only possible values of n are 1, 5, 7, 11, 13, 17. . . . Considering next the case of a three-phaser with a star grouping of its windings, the author points out

that those harmonics in the E.M.F. wave whose frequency is equal to the fundamental frequency multiplied by a multiple of 3 have no phase difference, but at any instant all act either towards or away from the neutral point, balancing each other. Hence it is that these co-phasal harmonics do not appear in the external circuit. If E_i stand for the r.m.s. value of the co-phasal harmonics in the E.M.F. wave of a single phase and E_p for the r.m.s. value of all the harmonics in that phase, then the effective r.m.s. value of the E.M.F. between two generator terminals is $\sqrt{3(E_p^2 - E_i^2)}$, which may in many cases be considerably below the commonly used value $E_p\sqrt{3}$. With a Δ connection of the windings, the co-phasal harmonics, although balancing each other so far as the external circuit is concerned, no longer do so as regards the armature, and give rise to local armature currents which increase the heat loss in the generator. These theoretical deductions are fully borne out by the results of a number of experiments carried out by the author, a brief account of which is given in the paper. A. H.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

1580. *York Corporation Electricity Works.* (Elect. Rev. 46. pp. 619–622, April 13, 1900.)—*System:* Low tension direct current, three wire, with accumulators. The boiler-room contains two 28-feet by 8-feet Lancashire boilers; working pressure, 125 lbs. The feed-water is heated by a 192-tube Green Economiser. There is a jet condenser to condense 25,000 lbs. steam per hour with a 26-inch vacuum. The engine-room contains two 3-crank GGGS and two 2-crank EE William engines driving directly 75-kw. 460 volt to 560 volt, and 24-kw. 230 volt Crompton continuous-current generators respectively. The former are suitable for lighting and traction and the latter are balancers. There are two motor-driven boosters for battery charging. Two armoured lead-covered concentric Callender feeders of 0·42 square inch section are laid directly in the ground. Distributors of similar make having a cross-section of 0·12, 0·06, and 0·12 square inch and 7/16 S.W.G. single arc cables are laid directly in the ground. The station is equipped with a 125-cell battery of Tudor accumulators in glass boxes having 250 ampere-hours capacity. The equivalent of over 7,000 8-c.p. lamps are connected and 3,000 more are being wired. Immediate extensions are contemplated. The price charged is 7d. for the first hour and 3d. afterwards up to 5,000 units per annum; 7d. and 2½d. from 5,000 to 10,000; 7d. and 2d. from 10,000 to 15,000; 7d. and 1½d. exceeding 15,000; 3d. for power and 3½d. for church lighting. There are photographic illustrations of some of the plant. J. T. R.

1581. *Greenock Electricity Supply Works.* (Electrician, 44. pp. 888–893, April 13, 1900.)—*System:* Continuous current three wire. The *boiler-room* contains two Babcock and Wilcox boilers, each having 1,827 square feet heating surface, and evaporating 7,000 lbs. water per hour, working at 200 lbs. per square inch. The boilers are fitted with B. and W. chain grates and superheaters. The feed-water is heated by a Berryman exhaust steam heater, and a 256-tube economiser. The coal is fired by mechanical stokers. The *engine-room* contains two Bellis 3-crank engines, each driving a 180-kw. Silvertown dynamo giving 300 amperes and 500 to 600 volts at 420 r.p.m. A balancer, consisting of two Silvertown dynamos each giving 200 amperes and 300 volts at 450 r.p.m., is driven direct by a Bellis engine. There are two motor-driven boosters, each giving 150 amperes at 50 to 150

volts, which may also be used as a booster balancer. Feeders of Callender's make are laid on the solid and, in some cases, the Callender-Webber systems. Three are two-wire, ¼ square inch area; one three-wire, 0·4, 0·2, and 0·4 square inch, and one 0·5, 0·2, and 0·5 square inch. Single 7/16 vulcanised bitumen lead-covered arc lighting cables are drawn into Callender-Webber casing or iron pipes. The station is equipped with a Tudor battery of 304 cells giving 800 ampere hours. There are 44 arc lamps run 11 in series off the 500-volt supply. The lamp-posts are constructed to carry trolley wires. *Drawings:* Scale drawings of generating sets and photos of the plant. J. T. R.

1582. *Electrical Transmission at Grosvenor Dale Cotton Mills.* (Amer. Electn. 12. p. 123, March, 1900.)—The Grosvenor Dale Cotton Mills consist of three large buildings, each of which is situated near a separate fall along the stream. The upper fall is of about 1,100 H.P., the next about 300 H.P., and the lower one about 450 H.P. The central mill, being too small to be operated with profit, was dismantled and the power of the fall utilised for operating an electrical plant to provide lighting and auxiliary power for the other two mills.

Two 150 k.w., Westinghouse, two-phase generators, delivering current at 2,200 volts, are installed. At the lower mill this pressure is transformed down, and 1,000 16-c.p. lamps are supplied. At the upper mill are four transformers which reduce the pressure to supply 2,200 16-c.p. lamps and several small Westinghouse induction motors operating at 200 volts. At this mill are two 100-H.P. Westinghouse two-phase motors taking current at 2,000 volts direct from the main generators. These motors are belted direct to the main shaft. The electrical equipment was guaranteed to operate successfully under a maximum variation of 3 per cent. of the steam-engine speed at the mill, and 5 per cent. of the water-wheel speed at the generating station. The results are satisfactory, the motors having often worked at from 30 per cent. to 40 per cent. overload. A double purpose is served by the two 100-H.P. motors. It was customary at first to throw off the motors when the lighting was put on the circuit, the water power available not being quite sufficient for both. But as the motors are connected to the shafting, they are held up to their normal speed by the steam-engine and automatically reverse their action, becoming generators and helping the main generators.

This feature affords a perfect automatic regulation, and enables the full power of the water-wheels to be utilised. The distance from the works to the upper mill is 6,000 feet, and to the lower mill is 1,800 feet. E. D. P.

1583. *Tonawanda Power Company.* (Amer. Electn. 12. pp. 155–162, April, 1900.)—At Tonawanda, ten miles from Buffalo and fourteen miles from Niagara Falls, the transmission line from the Falls Company to Buffalo, is tapped, and power from it is transformed, converted, and regenerated into the various kinds of voltages and current desired for traction, arc, and incandescent lighting and distribution to motors. The plant is principally Westinghouse.

The branch transmission to Lockport is also dealt with in this station, an instrument designed by P. M. Lincoln measuring directly the factor of the load curves on which the charges are based. This factor is the aggregate length of time per month during which the load drawn is greater than that contracted for. The instrument, which might be termed an overload-time meter, consists of a recording train measuring hours, driven by clockwork, the motion of which is stopped whenever the load is less than the normal amount which the circuit is supposed to take. When there is an overload upon the

line a pivoted armature is rotated by its laminated alternating-current magnet in such a way that the clock escapement is released, and the meter then commences to register.

The high-tension fuse used in this station consists of an aluminium wire about a foot long fastened to carbon clamps and stretched between the upper ends of two long wooden poles. At its lower end the shorter of these poles is hinged to the other. The wire fuses with 50 amperes, and directly it melts the hinged pole is forced outwards by a spring and then falls by gravity, giving a break of about 6 feet. By grasping the lower end of the longer pole the fuse breaker as a whole can be withdrawn from its knife contacts. The transformers are of the oil insulated self-cooling type, delta connected, each unit being rated at 500 kw. A peculiarity is that each transformer has two entirely independent secondaries, one of 4,400 volts for the distribution of 25 cycle power to outside consumers, and the other 360 volts for supplying the railway rotaries and the motors of the central station motor-generator sets. As the currents through the primary are the resultant of both loads, this arrangement allows of one service being considerably overloaded if the other is underloaded. As 11,000 volts are delivered in Buffalo, the pressure at Tonawanda rises at times considerably above this; the windings are therefore arranged to give various ratios.

The two 500-kw. rotary converters deliver 500-volt continuous current, and are compound wound and fitted with equalisers. They have magnetic oscillators, which move the shafts axially and thus prevent the brushes from wearing grooves into the commutator or collector rings. E. K. S.

1584. *Three-phase Transmission on the Union Railroad, Providence, R.I.* **B. Harding.** (Street Rly. Journ. 16. pp. 294–296, April, 1900.)—The Union Railroad Company of Providence is extending its lines into the surrounding country districts. The first of these extensions has a length of eighteen miles. The towns along the route are summer pleasure resorts built on the shore of Narragansett Bay. The power station in Providence has a total capacity of about 5,000 H.P. To supply current to the new extension line a substation has been erected at Riverview, fourteen miles from Providence. At this substation rotary converters are installed receiving polyphase currents from Providence and supplying the line with direct current. At the central station, Providence, there are two 300-kw. Westinghouse rotary converters, which receive direct current at 575 volts and deliver two phase alternate-current at 400 volts with a frequency of 60 cycles per second, when running at 600 r.p.m. These machines are guaranteed to give their normal output, 300 kw., for twenty-four hours without an increase of temperature exceeding 40° C. above surrounding atmosphere, and to carry 25 per cent. overload for ten hours, or 50 per cent. overload for two hours, or 90 per cent. overload for ten minutes, without injurious heating. These rotary converters are provided with separate shunt-wound exciters coupled to their shafts. The fields of these exciting machines are run considerably under saturation-point, so that any increase in speed of the rotary is followed by a large increase in its excitation. The object of this is to prevent the running away of the rotary, which is likely to occur if the direct-current side were simply run as a shunt to the mains, due to the considerable field-weakening effect caused by the armature reaction of lagging currents.

The two-phase currents of the converter are transformed by four 200-kw. Westinghouse self-cooling, oil-insulated transformers to three-phase 10,000 volt currents. This is transmitted by three No. 4 copper wires supported

overhead by Locke triple petticoat glass insulators to the Riverview sub-station. Here it is transformed by four Westinghouse transformers of 150 kw. each, to two-phase 400 volts. Additional terminals are provided for alternate-current connections corresponding to direct-current voltages of 550, 565, and 580 volts respectively. The current passes from the transformers to the two rotaries, which have a capacity of 250 kw. each. The high-pressure three-phase lines are carried overhead upon the poles of the Narragansett Electric Light Company within the city, and on the trolley poles outside the city limits, the wires being arranged in an equilateral triangle 18 inches apart.

The track outside the city limits is single, with turnouts at the stations; it is standard gauge and in good condition, having previously been used as a steam railroad. This track was formerly owned by the New York, New Haven, and Hartford Railroad Company, and was operated by steam. The fare charged from the Union station to Buttonwoods was 25 cents by the steam company; by the electrical company the fare is 15 cents.

Some illustrations are given of the rotary converters and also some particulars of the rolling stock and the times of service. E. D. P.

1585. *Southampton Tramways.* (Electrician 44. pp. 813–816, March 30, 1900.)—A preliminary description of temporary generating plant and ultimate scheme. It is proposed to charge a large 500-volt battery from 230-volt lighting dynamos in series during light loads, and to drive the cars from the battery alone during certain hours of the day when the lighting load is heaviest.

J. T. R.

1586. *Aberdeen Tramways.* (Tram. Rly. World, 9. pp. 5–10, Jan. 1900.)—*System:* Overhead trolley, continuous current. The *boiler-room* contains four 159-H.P. and four 96-H.P. Babcock and Wilcox boilers, 150 lbs. working pressure. The *engine-room* contains nine Willans and one Bellis engines, together indicating 2,000 H.P. Three engines indicating together 1,150 H.P. are for traction. Each of the three drives directly a Mather and Platt 550-volt, six-pole, compound generator. The track is equipped on the overhead centre trolley wire system: 30 ft. 6 in. steel poles carry, by means of bow bracket arms where the poles are between the tracks, and by span wires where the poles are on the footway, 00 B and S h. d. copper trolley wires, insulated by Ohio Brass Company's insulators. The rails are of girder type, 98 lbs. per yard, tied together by 2-in. × ½-in. ties, 5 feet apart. The fishplates weigh 78 lbs. per pair, and the joints are bonded by double Neptune 6/0 wire bonds. There are cross bonds at intervals of 40 feet. The foundation of the track is concrete 6 inches deep. The roadway is paved with 7 in. × 3½ in. × 7 in. granite setts. There are eight top-seat motor cars fitted with Brill trucks, two Westinghouse motors, seating capacity 28 outside, 24 inside. *Drawings:* Scale plan of generating station, section of track, rail section, and photograph of plant and track. J. T. R.

1587. *Ghent Tramways.* **J. Buse.** (Ind. Élect. 9. pp. 96–98, March 10, 1900.)—*System:* Accumulators on cars. The *boiler-room* contains three Piedboeuf boilers with 150 square metres heating surface and 4 square metres grate surface. The feed-water is heated by a Green economiser. The *engine-room* contains three 300-I.H.P. Corliss compound engines having cylinders 50 and 80 cm. diameter, 80 r.p.m., each driving by belt a Westinghouse six-pole generator giving 800 amperes and 250 volts at 400 r.p.m. There are three *panel* generator-switchboards fitted for charging accumulators. Two charg-

ing boosters increase the voltage to 280. The car-charging barn contains six trucks and 90 charging benches. The rails are of the Broca type, 47 kg. per metre, 16 cm. deep, 14 cm. broad at bottom. The 29 mm. groove was too narrow on curves and had to be increased by about 7 mm. There are 52 motor cars fitted with 15 H.P. 250-volt motors, and 108–150 ampere-hour cells, weighing 3,800 kg. with acid, grouped in series or parallel by the controllers, by which the speed can be varied from two to twenty miles per hour. The acid injures the cars. The town receives 17·5 per cent. of the gross receipts. The manufacturers maintain the cells for 1·1d. per car mile. J. T. R.

1588. *Copenhagen Electricity Works.* **C. G. Hoest.** (Elektrotechn. Zeitschr. 21. pp. 368–372, May 10, 1900.)—A description of the central station for light and power erected by the city authorities of Copenhagen for supplying the suburbs as well as the city proper. Peculiar circumstances affecting this are referred to.

The system adopted is three-wire continuous current. A large storage battery is installed, the voltage for light and power being arranged at 220 volts, and that for tramways at 250 volts. The division of the voltage of the generator is effected by means of the accumulator. The buildings are designed for an extension to three times the demand for which provision is now made. At present the H.P. is 4,400, of which 570 can be supplied by the accumulator. The accumulators are of the Tudor type, with a maximum discharge rate of 1,908 amperes for three hours. A somewhat special arrangement for working the regulating switches in the end cells in both charge and discharge is described, and a diagram given of the switchboard connections.

Babcock and Wilcox boilers are used, and are fitted with induced steam draught on Granger's system for burning small coal. The feed-water is taken from the mains of the Copenhagen Water Company, and is first put through a cleanser in which a mixture of lime and soda causes a deposition of deleterious matter without heating. Large reservoirs are provided for the cleansed water from which the feed-pumps take the supply. E. C. S.

1589. *Perth (W.A.) Electric Tramways.* (Street Rly. Journ. 16. pp. 288–293, April, 1900.)—*System:* Overhead trolley. The boiler-room contains Babcock and Wilcox boilers, working at 160 lbs. pressure. Water is obtained from an artesian well which has a capacity of 375,000 gallons per day. The engines are tandem, compound, of 300 H.P. each, built by the Robb Engineering Company, Nova Scotia. They are direct coupled to General Electric generators, yielding 550 volts at 150 r.p.m. The plant is run non-condensing at present, but arrangements are made for installing condensers in the future.

The overhead line work consists of wrought-iron tubular poles of 4 in., 5 in., and 6 in. sections, set in the ground to a depth of 6 feet, and embedded in concrete. They are fitted with a malleable iron four-pin cross-arm. Cup and cone hangers, 15 in. ears, wooden span-wire insulators, No. 00 trolley wires, and No. 000 feeders are used throughout the work. Great difficulties were experienced in the erection of the overhead work, chiefly due to the large number of electric light, telegraph, and telephone wires over the streets. At one street-crossing no less than 750 wires were found, the lowest of these being only 15 feet above the head of the rail. In some cases, some of these wires were cabled, but the greater part of the work necessitated the setting of higher poles and the raising of the cables and wires.

The rails used are 9-inch, 84-lb. grooved girder, 30-feet lengths ; the joint-

plates are 36 inches long, fastened with twelve 1-in. bolts. They are laid on jarrah ties, 6 in. × 8 in. × 6 ft. 6 in., placed 2 feet between centres. A 3 ft. 6 in. gauge, the standard of the Western Australian Government railways, is adopted, and was specified in the concession. Tie rods are used 6 feet apart. The rails are bonded with two No. 0000 flexible horseshoe bonds, and the track is cross-bonded every 120 feet. Wood paving is used, blocks of jarrah, 3 in. × 9 in. × 6 in., being laid on concrete foundation 6 inches thick. Owing to the excessive expansion of the paving during the wet season, it was found necessary to insert "mastic" joints between the blocks at fixed points. These joints consist of ribbons or sheets of asphalt and tar to take up expansion and prevent buckling.

The rolling stock consists of ten 18-feet closed cars of the centre-aisle, cross-seat pattern, seating 28 persons; and ten standard closed cars with longitudinal seats. All the cars are mounted on Brill's E21 trucks, with 4-inch axles and equipped with G.E. 58 motors.

The article includes several illustrations showing the track and generating works during construction and when completed. E. D. P.

1590. *Special Operating Problems in Brooklyn.* **R. L. Russell.** (Street Rly. Journ. 16. pp. 338-341, April, 1900. Paper read before the New York Railroad Club, Feb. 15, 1900.)—Details are given of the various central stations, of which the following are some of the leading particulars :—

Name of Station.	No. of Babcock and Wilcox boilers.	Generators.	Capacity of Coal Conveyer.	Chimney.
Fifty-second Street	16 of 250 H.P. each, or a total of 4,000 H.P.	12 of 500 kw. each 2 of 375 ,, Total, 6,700 kw.	60 tons per hour	One brick stack 12 ft. in dia. 206 ft. high
East River Station	34 arranged on double deck boiler houses; total H.P. 8,500	4 of 1,500 kw. each 2 of 1,600 ,, Total, 9,200 kw.	70 tons per hour	
Ringwood Power Station	8 of 250 H.P. each, or a total of 2,000 H.P.	6 of 300 kw. each Total, 1,800 kw.		Four iron stacks each 4½ ft. in dia. 100 ft. high.
Third Avenue Power Station	12 having a total rated H.P. of 5,000	8 of 500 kw. each 2 of 800 ,, Total, 5,100 kw., besides two 200 kw. boosters		One brick 8½ in dia. 150 ft. high Two iron stacks 6½ ft. in dia. 125 ft. high
Thirty-ninth Street Station	10 having a total rated H.P. of 25,000	2 of 1,120 kw. each 2 of 660 ,, Total, 3,560 kw., besides a 560 kw. booster		One iron stack 8½ ft. in dia. 165 ft. high

Particulars are given of how the special conditions of certain lines carrying excursion traffic were met by the use of boosters. On the Sixty-fifth Street to Coney Island line, 6·13 miles long, double track, which in the season carries as many as 105,000 passengers per day, the carrying capacity of the copper conductors was the only thing considered, the idea being to put up as little copper as possible. The cars are spaced as closely as possible, and the highest reading taken is 2,060 amperes or 1,380 H.P. To keep a uniform voltage so that a high-speed schedule can be maintained, there are specially designed boosters, direct connected to engines, which are wound to give any desired increased pressure from 25 to 400 volts above that of the power

station. The method has worked with entire satisfaction, the average voltage during the heaviest hours varying from 486 to 510.

For the heavy electric elevated trains over the Brighton beach line, it is proposed to install a secondary battery to help in giving the large currents taken at starting the train. E. K. S.

1591. *Detroit, Rochester, Romeo, and Lake Orion Railway.* (Street Rly. Journ. 16. pp. 286–288, April, 1900.)—Commencing at Detroit, this railway runs for a short distance over the lines of another company; then over its own track to Rochester, 15 miles; here it divides, one branch going to Romeo, 12 miles; the other branch to Lake Orion and Oxford, 13 miles. The power station is at Rochester. The boiler house, 47 feet × 70 feet, contains at present two 250 H.P. boilers. There are two Deane feed pumps, each capable of supplying a 500 H.P. boiler with water; injectors of the Metropolitan type are also installed, and are connected to both the creek and the city water mains. The feed-water is brought from a creek, 300 feet away, through a 6-inch cast-iron pipe, in which is a Worthington strainer. The injection water for the condensers also comes from this creek in a 10-inch cast-iron pipe, and is discharged back into the creek through a 15-inch terra-cotta pipe. The engine-room, 50 ft. × 70 ft., contains two 325 H.P. tandem compound condensing Ball and Wood engines, running at 200 r.p.m. Goubert heaters are placed between the low pressure cylinders and the Deane jet condensers; the feed piping is so arranged that one or both heaters may be used, or a supplementary heater (fed by exhaust from feed and vacuum pipes); water relief valves are placed on each heater and feed pump. Crocker-Wheeler generators are used, 200 kw., 550–650 volts, and direct coupled. A booster set is also installed, consisting of a 150-ampere, 600-volt motor, mounted on the same base with a generator having a capacity of 400 amperes at 150 volts. This generator is in series with the line, and can raise the pressure of the booster feeder from 650 volts to 800 volts.

The track is laid with 56-lb. 60-feet rails on cedar ties, with oak ties at curves and special work. The joints are fastened with six-hole fishplates and protected rail bonds are used. The whole track is ballasted with gravel, of which there is a depth of 6 inches below the ties. Turnouts are 4 miles apart, with telephones at each. Double trolley wire, 00 figure 8, is used, feeders being tapped into it at every half-mile. The poles are of cedar.

The rolling stock consists of eight Kuhlman cars, 45 feet over all, weighing 21 tons, and seating capacity of fifty-four. Two 65-H.P. Westinghouse motors are on each car; the brakes used are of the Magann stored air type. Kalamazoo trolley wheels are used, and are found to run from eighty to ninety days.

The company also furnishes the city lighting for Rochester. The equipment for this consists of a 150-H.P. 550-volt motor, direct coupled to a 90-kw. Westinghouse alternator, which operates at 11,000 volts. A Chapman voltage regulator is used, and by this means the town lighting pressure is regulated to within a 2 per cent. variation. E. D. P.

1592. *Dayton (Ohio) Electric Railways.* (Street Rly. Journ. 16. pp. 277–285, April, 1900.)—The street railways of Dayton are operated by three separate and distinct companies. Each company has its own car houses, and its own shops, and all have been remarkably successful. Previous to this year there had already been built two railways of 25 miles and 84 miles in length respectively. The three new lines which started operating in January of this year

are the Dayton, Springfield, and Urbana, 48 miles; the Dayton and Xenia, 33 miles; and the Dayton-Xenia Rapid Transit, 18 miles long.

Dayton, Springfield, and Urbana Electric Railway.—The line is double track in both Dayton and Springfield, but is otherwise a single line, with turnouts, and is constructed entirely on a private right of way, varying in width from 50 feet to 300 feet.

One generating station is at Medway, the centre of the Dayton-Springfield section; the other, in course of erection, is at Bowlersville, on the Urbana section, and both are of quite similar construction and equipment. The boiler-room, 55 ft. × 43 ft. 4 in., contains three 250-H.P. Babcock-Wilcox boilers, Blake pumps, Goubert heaters, Stratton separators, and Chapman valves. The station is located on Mad River, and has an abundant water supply. The equipment of the engine-room, 99 ft. × 50 ft. 8 in., consists of three Slater cross compound condensing Corliss type engines, 450 H.P. each, 100 r.p.m., direct coupled to three 325-kw. Westinghouse generators. One 100-kw. Westinghouse booster is used.

The overhead city construction is side pole, with steel poles 28 feet long, in two sections; the lower section, 6-inch pipe, 20 feet long, the upper section, 5-inch pipe, 8 feet long with the joint 18 inches long, swedged and turned on top to shed water. Spans are attached by pole-bonds, with Creaghead strain insulators at the pole, and glass brake knobs are placed in the spans 4 feet on each side of the trolley wire. The rest of the road is equipped with Creaghead flexible brackets, 10 feet long, supported on wooden poles 7 inches diameter at the top, and of lengths sufficient to bring the top cross-arm 24 feet above the track. The poles have two four-pin cross arms, the upper one for the telephone and block signal system, and the lower one for feeders. In Dayton 95-lb. girder rail is used; in Springfield and Urbana 95-lb. girder section. All rails are in 60-feet lengths, laid on 6-in. × 8-in. × 8-ft. ties. The inter-urban sections are laid with 75-lb. rails. The joints are made with six-hole fishplates, which conceal two ·0000 Crown rail-bonds. The rails are also cross-bonded, and wherever a stream is crossed a heavy copper ground-plate is used. After the subgrade was completed and ditched a layer of 12 inches of gravel was put on; the ties were covered with the same material, thoroughly tamped. Plate girder bridges resting on stone abutments are used for crossing small streams. There are also three Pratt truss bridges on the line of 156-feet, 136-feet, and 80-feet spans. There are fourteen passenger cars, four combination passenger and baggage cars, one snow plough, and a special Pullman car for parties. Each car is equipped with four B47 G.E. motors. Ten have G.E.C. electric brakes, and the rest are fitted with Christensen air brakes.

Dayton and Xenia Traction Company's Line.—The generating station is situated near the centre of the Xenia section, on the Little Miami River, which provides an abundant water supply. The boiler house contains four 250-H.P. Cahall vertical boilers, Cochrane heaters, Buckeye separators, chain grates, Stilwell-Bierce and Smith-Vale pumps and condensers, and Metropolitan injectors. The engine-room contains two 750-H.P. cross-compound Buckeye engines, direct coupled to 500 kw. Westinghouse generators. The track is constructed of T-rail, 90-lb. on the Xenia section and 80-lb. on the Spring Valley section. In Dayton 95-lb. grooved rails and in Xenia 90-lb. girder rails are used. All rails are laid on oak ties, 6 in. × 8 in. × 8 ft., spaced 2 feet apart centre to centre, and bedded in gravel. Where the line crosses small streams oak trestles have been erected; there are also several steel bridges on the line. Side pole span

construction is used in the cities and villages. The steel poles are in three sections 28 feet long, set in concrete ; on the interurban lines 30-feet poles with 7-inch tops are used.

The rolling stock consists of six passenger cars, two passenger and baggage cars, six open single truck cars, one freight car, one single truck repair car, and one snow plough. The passenger cars are equipped with Christensen brakes, and each car carries four Westinghouse 56-A motors. The road is operated by a telephone system, in connection with a block signal system.

Dayton and Xenia Rapid Transit Railway.—The power house is situated on the Little Miami River, which provides an abundant water supply. The boiler room contains four 200-H.P. horizontal water-tube boilers. The engine-room contains two 500-H.P. Lane and Bodley Corliss engines driving by belt two 400-kw. G.E. generators. Iron pole span construction is employed in Dayton; the rest of the line has wooden poles, to which are attached Creaghead flexible brackets. The track is of 70-lb. T-rails, joined by six-hole angle bars 30 inches long. The joints are bonded each with one No. 0000 Atkinson rail bond. The rails are laid on oak ties 6 in. × 8 in. × 8 ft., spaced 2 feet centres and bedded in gravel.

The article is fully illustrated, and also deals with proposed further extensions of the electric railways of Dayton. E. D. P.

1593. *The Langen Monorail Suspended Railway at Elberfeld-Barmen.* (Engineering, 69. pp. 412–413, March 30, 438–441, April 6, 501–503, April 20, 1900.)—A brief review of monorail systems and some of their advantages and defects. The Elberfeld-Barmen line is 8¼ miles long, 6·2 of which are above the River Wupper, whose width varies between 68 feet and 115 feet. A number of extensions are contemplated, but these will be electric surface trains. The sharpest curve on the track proper is 295 feet radius, but there is one close to the Vohwinhel terminus of 100 feet, and on the sidings 26 feet radius. The maximum gradient is 1 : 22. The actual speed is 31 miles per hour, which can be attained in 15 seconds. It will be possible to keep up an average speed, including stoppages, of 20·5 miles per hour. The stations are about 0·4 mile apart. The construction of the track is described and illustrated.

The trains, which consist of two carriages, but may be increased to four, are driven electrically, the supply of current to the two lines being entirely separate. A common parallel series car controller, for all motors, is in the first carriage. At both ends of each car, accessible to the guard, are levers of the hand brakes, Westinghouse automatic brake and circuit breakers. Five 4-in. pipes 56 feet long beneath the floor of the car serve as air cylinders, which are filled with compressed air at 115 lbs. per square inch at the termini.

Each car is suspended from two 2-wheel bogies. Each bogie is fitted with a 36-H.P. electric motor driving the wheels by spur gearing. The round rail-heads form the centre about which the whole carriage can oscillate. The cars, which are constructed of steel lined with wood, carry fifty passengers, and weigh fourteen tons when full. Current consumption does not appear to be greater than on surface tram cars, which do not attain half the speed. The automatic block system, which permits of a two-minute service, the signalling arrangements and the stations are described, as are other types of Langen railways. *Drawings.*—Scale plan and gradients of route, details of construction of track, plan of terminal station and siding, and scale-drawing of carriage. J. T. R.

ELECTRIC TRACTION AND AUTOMOBILISM.

1594. *Coal Consumption in Steam Power Plants for Electric Traction.* **A. della Riccia.** (Écl. Électr. 23. pp. 121–130, April 28, 1900.)—A commentary upon a paper by A. B. Herrick (see 1900, Abstract No. 974). The subdivision of losses outside the generating station is discussed in detail, and also the selection of the type of steam engine, boiler, and steam pressure with reference to *elasticity* of the plant, *i.e.*, its capacity for dealing with sudden and large increases of load, *economy* or the attainment of a high degree of efficiency under the varying conditions of load, and "promptitude," or the rapidity with which the generating plant will respond to variations of load great and small.

Calculations are given from which it appears that the mean efficiency of generating units, within the conditions of variable load assumed, increases with the H.P. of these units in a greater ratio than the maximum efficiency. The author arrives at the following interesting conclusion in connection with the use of a battery of accumulators as an equaliser. Assuming that 40 per cent. of the energy supplied by the battery to the line is lost in the battery itself and in the various apparatus for its regulation, it would appear that from the point of view of coal consumption alone, the value of an accumulator in electric tramway systems of varying sizes, but in which the proportional load variations are similar, diminishes as the power generated increases, until a point is reached (apparently at about 300 H.P. units), when the saving effected by the accumulator vanishes altogether. E. C. S.

1595. *Electric Traction under Steam Railway Conditions.* **E. C. Boynton.** (Amer. Inst. Elect. Engin., Trans. 17. pp. 1–19, Jan., 1900.)—There are three methods of using electricity as a motive power on a steam railroad. (1) By electric locomotives. (2) By standard coaches equipped as motor cars. (3) By special light motor cars and trailers and the withdrawal of standard coaches.

The first method is good where the traffic is heavy, the speed high, and service frequent, especially if the same trains run over both steam and electric lines. The cost of repairs is only about 10 per cent. of that of a steam locomotive. The second method is cheap and convenient. The motor car carries its own paying load, and can be run light when required. The cost of converting a standard coach is about \$3,800 when two motors are used. The third method reduces the dead-weight hauled, which means economy of power, the cars are cheaper to construct, and the wear on the rails is less. The cost of maintenance is greater with the lighter cars.

For transmitting the power a third rail construction is cheaper to maintain and construct than a trolley line. The former can be efficiently insulated by being supported on wooden blocks dipped in some insulating compound and attached to the sleepers. Feeders are not often necessary, as there may be only two, or at most three trains running at the same time. T-rail, when used for the third rail, is very difficult to bond satisfactorily.

The power stations required on converted steam railroads do not differ from those for ordinary street railway work. They cost about \$80 to \$90 per kilowatt to build.

The cost of a three-car steam train kept constantly moving for about nine hours, and covering 150–200 miles is about 30 cents per mile at least. A three-car electric train, one of the cars being a motor car, can be run for 14 cents per mile, whilst doing the same work.

Steam roads which have introduced electric motive power find it cheapest

and most satisfactory to supply their own current for lighting their stations and freight-houses. A simple way is to wire the lights in groups of five or six in series, and connect directly between the working conductor and the ground. A battery and rheostat can be connected in parallel with the lighting load, acting as a regulator. P. D.

1596. *Electrolysis by Earth Returns in Chicago.* **E. B. Ellicott.** (West. Electn. 26. p. 87, Feb. 10, 1900.)—Within the last two years many cities have experienced serious troubles from the bursting of water mains, and in nearly every instance the primary cause of the bursting was due to the deteriorating effect of the return current from a street railway. Some of the conditions in Chicago are especially bad, and no effort seems to be made by the companies to make such corrections as may be in their power. The situation is now such that nothing but a combined effort of all companies will clear up the dangerous conditions and relieve the companies of a liability that will surely be placed upon them by the courts.

It is the practice in street-railway work to bury under the rails a large amount of copper wire, and at points varying from 25 feet to 1,000 feet apart, to connect this wire to the rails with copper connecting wires. The importance of good bonding and connecting is illustrated by an example in Chicago, where the drop in potential in one mile of track and supplemental copper-return wire was 8½ volts. After three bad bonds had been replaced, a drop of only 2½ volts was shown. A water-pipe ran parallel to the track for a considerable distance, and, before the change in bonds, it was found to be 1 volt positive to the rails at two places. After the change in bonds the potential between the rails and water-pipes was about one-thirtieth of a volt at all points.

After a careful study for over two years, the author has recommended a clause to be inserted in an ordinance recently passed by the council, requiring the railway company to provide and maintain a return circuit of such conductivity that the *maximum potential* between any part of the return circuit and the water-pipes should not *exceed one volt*, and also providing that there should not be a *variation* in potential of more than *one-half volt* between any *two* points within a *distance of* 300 *feet*, measuring along the line of the railway. Under these conditions there will be some flow of current to and from the water-pipes, but with the one-half volt variation the disintegrating effect will be distributed over a large area of water-pipe. The author maintains that the only excuse for using a grounded return circuit is the question of economy in construction and maintenance. E. K. S.

1597. *Working Expenses of Electric and Cable Railways.* (Tram. Rly. World, 9. pp. 138–139, April, 1900.)—A comparison of the financial results of the Liverpool Overhead and City and South London Electric Railways, and the Glasgow District Subway worked by cable traction.

Table I. gives particulars of the three railways relating to the last half-year, in addition to those given in Abstract No. 1287 (1899), and Table II. (which is abstracted from the particulars in the article) gives the financial results for the last six half-years.

TABLE I.

	Liverpool Overhead.	City and South London.	Glasgow Subway
Receipts per passenger carried	1·96d.	1·92d.	1·26d.
Train miles run per double-track mile ...	59,666	80,598	82,809
Passengers carried per double-track mile	772,956	1,147,647	1,059,310

TABLE II.

Name of Line.	Half-Year.	Per Train Mile—Pence. Maintenance of Way, Works, and Stations.	Locomotive Power.	Car Repairs and Renewals.	Traffic Expenses.	General Charges, Taxes, &c.	Total Expenses	Receipts per Train Mile.	Totals. Per cent. of Expenses to Receipts.	Total Expenses.	Total Receipts.	Miles Run.	Passengers Carried.	Remarks.
Liverpool Overhead Electric Railway.	June, 1897	1·8	3·42	0·29	5·41	3·26	14·18	23·79	59·6	21,459	36,026	363,399	4,269,260	Time during which workmen's tickets available has been extended.
	Dec., 1897	2·16	3·71	0·38	5·12	3·44	14·81	24·25	61·07	22,940	37,559	371,773	4,467,490	
	June, 1898	1·89	3·93	0·46	5·59	2·74	14·61	24·63	59·32	22,076	37,220	362,690	4,472,941	
	Dec., 1898	2·14	3·91	0·53	5·57	2·77	14·92	26·12	57·12	23,218	40,656	373,560	4,894,921	
	June, 1899	1·8	4·31	0·46	5·79	2·74	15·1	23·32	64·75	23,624	36,492	375,500	4,475,279	
	Dec., 1899	1·29	4·17	0·27	5·4	2·58	13·71	25·42	53·93	25,007	42,662	402,752	5,214,957	
City and South London Electric Railway.	June, 1897	0·59	6·11	0·57	6·25	2·7	16·22	29·15	55·64	15,734	28,260	232,703	3,437,810	Very keen competition with L.C.C. tramways. Cost of fuel no material effect.
	Dec., 1897	0·62	5·83	0·48	6·08	2·65	15·66	27·63	56·68	15,035	26,528	230,396	3,337,861	
	June, 1898	0·76	5·85	0·56	6·03	2·72	15·92	28·1	56·65	15,614	27,552	235,342	3,478,977	
	Dec., 1898	0·83	5·65	0·56	6·17	2·67	15·88	28·28	56·15	15,498	27,588	234,166	3,462,814	
	June, 1899	0.79	5·85	0·48	6·14	2·91	16·17	28·69	56·36	15,851	28,125	235,254	3,540,098	
	Dec., 1899	0·67	5·85	0·48	6·09	2·75	15·84	26·87	58·95	15,968	27,506	241,973	3,442,942	
Glasgow District Subway Cable Traction.	July, 1897	0·88	2·14	0·35	1·63	0·74	5·74	12·01	47·79	12,205	25,541	510,161	4,178,215	Fares very low. Route circular. Expenses per train mile much increased by higher wages and dearer coal.
	Jan., 1898	0·7	2·99	0·39	1·85	1·22	7·15	12·98	55·08	16,492	29,937	553,307	5,450,177	
	July, 1898	0·76	3·0	0.4	2·08	0·94	7·18	14·44	49·72	16,247	32,682	543,114	5,779,119	
	Jan., 1899	0·83	3·02	0·41	2·08	0·79	7·13	15·54	45·88	16,474	35,925	554,770	6,666,082	
	July, 1899	0·82	3·16	0·24	2·47	0·99	7·68	15·78	48·67	17,520	35,977	547,083	6,505,221	
	Jan., 1900	0·75	3·08	0·23	2·57	1·3	7·93	16·2	48·95	18,471	37,744	558,961	7,150,342	

The Glasgow expenses are only about a halfpenny per passenger, while those of London and Liverpool are about a penny. Glasgow runs the largest number of train miles per mile of track, but its train is the smallest. E. K. S.

1598. *Electrolysis by Earth Returns.* **A. A. Knudson.** (Amer. Electn. 12. pp. 119-120, March, 1900.)—The author is of opinion that the independent return is not the absolute cure for electrolysis which some believe it to be. He has measured a number of joints in water mains, and generally found their resistance to be proportional to the length of time they have been in the ground; thus, in some tests on 27 joints on 4-in. and 6-in. pipes it was found that in eleven months some had doubled, some trebled in resistance, whilst others had increased as much as sixty times. Before ordinary water-pipe lengths are laid they are treated with asphalt varnish inside and out, and when laid together lead is run in. Now if in the caulking process the lead touches the iron in any place galvanic action is set up, and this, added to ordinary corrosive effects, causes the resistance of the joint to increase year by year. The effect of such resistance causes any current which may be passing along the water-pipes to leave the positive end of the pipe and pass through the earth around the joint, to the end of the next length, or the current may pass through the water in the pipe and cause electrolytic pittings inside. The author is of opinion that pipes which have been underground five years or longer should *not* be connected with street railway systems. In other words, the older the water-pipe the less able it is to carry current without damage to itself. In criticising another suggestion, viz., to use a generator of low voltage at the power station to lower the potential of the piping, the author says that any method which compels the water-pipes of a city to act as a return conductor for railroad circuits is wrong in principle to begin with, and detrimental to the piping system in the long run. If water and gas mains were continuous conductors, like lead-sheathed cables having *no* joints, then the problem would be less difficult. Seeing, however, that things are as they are, there is nothing in sight as an absolute cure for electrolysis except to abandon the earth, as the telephone companies had to do when the overhead trolley came in. This means double-overhead or underground systems, and it may be mentioned that the former has been adopted on Cincinnati and on some of the Washington lines. E. K. S.

1599. *Motors for Electric Automobiles.* **P. M. Heldt.** (Elect. World and Engineer, 35. pp. 360-361, March 10, 1900.)—Considerations of efficiency lead to the use of relatively heavier motors than have been usual for tramcars, which do not have to carry their own power storage. The motors generally weigh about 10 per cent. of the loaded vehicle. Devices for avoiding differential gear are numerous. Monnard uses a motor having two independent armatures in a single field, and thereby saves weight over any two-motor arrangement. Another device is to have a motor with armature and field both revolving in opposite directions, thus doubling the relative speed of the members, and consequently the output per lb. The drawbacks to this are extra bearings and the necessity for contact rings. Another innovation is the hub motor, in which the motor field forms part of the hub casing and turns with the wheel. The armature turns free on the vehicle axle. To the hub casing is fastened an internal gear, and to the armature spider a pinion. These two are connected by intermediate gear running on a stud which is held by an arm secured to the stationary axle. E. H. C.-H.

1600. *Electric Automobiles in Chicago.* (West. Electn. 26. pp. 143–145, March 10, 1900.)—The Illinois Electric Vehicle Transportation Company is now running 72 hackney carriages at a charge of 25 cents per mile for two-seated vehicles, with a minimum of 50 cents ; and double rates for four-seated vehicles. These charges are less than for horse cabs. The company have extensive works where the cars are housed on two floors, with an Otis lift between. When a cab returns to the station after a trip it is immediately run up to one of two loading stands, which consist of a horizontally moving plunger rod, with hooks on one end, moved back and forth by means of a hand wheel and worm gear. The battery tray in the cab is clutched by the hooks and is drawn out upon a truck which is about as high as the battery receptacle of the vehicle. The battery is then drawn away from the stand and tested for specific gravity. A voltmeter reading is also taken on each cell while the battery is discharging at a 10-ampere rate. Acid is added if required to keep the specific gravity at 1·25. After being tested, the battery is run up to an outlet along the wall to be charged. The outlet of each charging circuit consists of a wooden frame which is slipped over the battery, and which is provided with automatic contacts that throw the cells into a series arrangement. The battery of each hansom and brougham contains 48 chloride cells arranged in two equal groups and giving 100 ampere-hours discharge at a 10-hour rate. The cell-cases are of hard rubber open at top. A battery with tray weighs about 1,400 lbs., and will run about 20 miles. Complete records are being taken, but are not published. Two charging pressures are used, 113 volts and 120–125 volts. When an exhausted battery is connected to the charging terminals it is first thrown on to the low-pressure 'bus-bars in circuit with a resistance of three ohms, and takes a current of about 35 or 40 amperes. As the amperes fall, the resistance is cut out gradually ; and finally, at about 10 amperes, the circuit is thrown on to the high 'bus-bar, with the full resistance, at about 30 amperes. This resistance is cut out as before, until the current drops to about 8 or 10 amperes with no resistance, when the battery is regarded as fully charged. It usually takes four hours to fully charge an exhausted battery. Arrangements are also provided for slow charging and forming, and the company intend to put every battery on a slow charge (10-ampere rate for 20 to 24 hours) at least once every two weeks.

After midnight the batteries are removed from all carriages, partly for inspection and partly to relieve the springs. An overhead trolley-wire is being provided for shifting carriages in the depôt. E. H. C.-H.

1601. *Electric Vehicles.* **A. Delaselle.** (Locomotion Automobile, 7. pp. 342–343, May 31, 1900.)—A general description of the Kriéger and the B.G.S. cars which took part in the "Criterium" organised by "Le Velo" for electrically propelled vehicles. The Kriéger car weighed complete, with two passengers, 2,140 kg. ; the accumulators weighed 1,057 kg. Fulmen accumulators were used, 42 cells of the B27 type and 36 of the B13 type being employed ; the capacity of the former is 220 ampere hours (5-hour discharge) and of the latter is 102 ampere hours. The car completed 170 km. without recharging. The B.G.S. car weighed 2,300 kg. without passengers ; the batteries consisted of two sets of 44 cells, connected in parallel ; each cell weighed 14·4 kg. and the capacity was 320 ampere-hours. A. G. N.

ELECTRIC LAMPS AND LIGHTING.

1602. *Photometric Comparison of Illuminating Globes.* **R. B. Williamson** *and* ***J. H.* Klinck.** (Frank. Inst., Journ. 149. pp. 66–74, Jan., 1900.)—The

globes were used in connection with Welsbach burners. The standard of light was also a Welsbach burner and screen. The light distributing properties of the globes is investigated, the intensity of the light emitted in the various directions being found in the usual manner by reflection from a mirror. The mantles remained quite constant and were discarded upon the first sign of breakdown. When one of the mantles gave out, both were renewed. It was found that the mantle is very sensitive to changes in the condition of the air; with the room at all close, it was impossible to obtain satisfactory results. On the other hand, too much ventilation caused dancing of the flames, but the effect of this when occurring only slightly was satisfactorily annulled by the slits in the screens. Curves of the results are given, showing in each case the results with the bare lamp and with the globe on, the same mantle being used for each pair of tests. Holophane, ground-glass, opal, and reflector globes of various shapes were tested; no ornamental or coloured globes were used. The lamps were each used with the ordinary Welsbach mica chimney over the mantle in all cases.

E. D. P.

1603. *The Combinations of Arc Lamps of Different Types.* **P. Girault.** (Ind. Élect. 9. pp. 109–111, March 25, and pp. 137–139, April 10, 1900.)—The author divides arc lamps into three principal types: (1) Constant potential lamps, (2) Constant current lamps, (3) Lamps with constant apparent resistance. He then examines what combinations of these can be used in distributions at constant current and at constant potential. In distributions at constant potential we cannot place constant current lamps in series, for if there were more than one they would divide up the difference of potential between them in any way. On the contrary, we can place in series any number of constant potential lamps or lamps having constant apparent resistance, however great the number; but in the case of lamps at constant potential, good regulation requires the insertion of a regulating resistance. Lamps having constant apparent resistance regulate well whatever the value of the regulating resistance, whether zero or finite. A constant current lamp can be joined in series with any number of—(1) Lamps of similar type, (2) Constant potential lamps, (3) Combinations of both types, even when the regulating resistance is zero.

In the second article the author discusses the imperfection of the regulation of constant potential lamps and shows that the mode of regulation produces greater variations of current in these lamps than in lamps having constant apparent resistance. The regulation of most lamps seems imperfect at the moment of lighting and the placing of a constant current lamp in a circuit comprising lamps of other types is advocated, since we then have in the circuit two modes of regulating.

The different combinations enumerated offer numerous applications: (1) The voltage of an installation under 70 volts can be easily raised in order to place two lamps in circuit in place of one—whatever the type of the original lamp; (2) If an installation of constant potential lamps and lamps of constant resistance regulates badly owing to too great fluctuations of current we can replace all the former lamps by those of the latter type, or, better, by constant current lamps; (3) It is often possible to transform an installation of two lamps at 110 into three lamps at the same potential by the insertion of a suitable constant current lamp; (4) In new installations it will often be advantageous to combine lamps of different types.

In distribution at constant potential one can employ indifferently either constant potential lamps or those having constant apparent resistance.

W. G. R.

1604. *Bardon Arc Lamp.* **Aliamet.** (Électricien, 19. pp. 321–324, May 26, 1900.)—In the upper part of this lamp there is arranged a rocking-frame, to the opposite ends of which the cores of the regulating solenoids are respectively attached. On opposite sides of the axis there are also attached pulleys, and a cord passes from one carbon-holder over one of these pulleys, then under a pulley mounted on a brake-wheel arbor, then over the other pulley on the rocking-frame and has its other end attached to the other carbon-holder. The brake-lever is pivoted at one end to the frame of the lamp, and has its other end weighted and attached by a sliding connection to one side of the rocking-frame. The core of the shunt solenoid is weighted, and is connected by a rod to a piston working in a cylinder serving as a dash-pot, a small amount of lost motion being provided in the connection between the rod and piston.

When the current is turned on, the frame is rocked so as to strike the arc, the brake-lever released so as to lock the brake-wheel by the action of its weight, and the length of the arc determined by the relative strengths of the pulls of the two solenoids on their cores. As the carbons burn away the pulls alter, the frame rocks, the brake-lever is raised so as to release the brake-wheel, and the carbons are moved towards each other by the preponderating weight of the upper carbon-holder. Fourteen hundred of these lamps are in use at the Paris Exhibition.

C. K. F.

1605. *Charging for Electrical Energy.* **W. W. Lackie.** (Inst. Elect. Engin., Journ. 29. pp. 678–689; Discussion, pp. 689–690, May, 1900.)—Dividing the total costs of production into standing and generating costs, the author apportions the former as follows, in the case of the Glasgow Corporation Electricity Department:—

	Cost per kw. £	s.	d.	Depreciation. Rate.		£	s.	d.
Land and buildings	14	0	0	1	per cent.	0	2	9
Machinery	25	0	0	7½	,,	1	17	6
Accumulators	2	0	0	10	,,	0	4	0
Mains and Cables	44	0	0	2½	,,	1	2	0
Meters	4	0	0	6	,,	0	4	9
Instruments	0	18	0	5	,,	0	0	11
Office Furniture	0	2	0	5	,,	0	0	1
Total per kw.	£90	0	0		Total	£3	12	0

This amounts to 4 per cent. on the capital for depreciation, while interest at 3·1 per cent. and sinking fund at 1 per cent. make up the total to 8·1 per cent., or £7 5s. 9d. per kw. installed. To this is added £1 10s. 3d. for rent, rates and taxes, and management, making £8 16s. in all for the standing charges.

The generating costs are as follows (1899):—

Coal	0·54d.
Oil, &c.	0·06d.
Wages	0·26d.
Repairs	0·42d.
	1·28d. per unit.

The maximum demands of all the consumers aggregate 70 per cent. of the *supply* applied for, while the maximum demand on the station is 50 per cent.

of the same. Taking the former value, each consumer must pay £6 4s. per kw. per annum + generating costs. In Glasgow this may be done by paying twelve monthly instalments of 10s. 4d. per kw. + 2d. per unit, or 4d. on each of 365 units per kw. + 2d. per unit, *i.e.*, 6d. per unit for 365 hours' use of the maximum demand per annum, and 2d. per unit afterwards. Customers who agree to pay for 1,825 hours' use of the maximum demand per annum are charged a uniform rate of 2d. per unit.

A comparison with the corresponding charges in the Gas Department is given, showing that the maximum demand system is inapplicable to the latter.

The author next points out certain reductions likely to be made in the future, making a capital cost £65 per kw., and the standing charges £3 17s. per kw. instead of £6 4s. The prices might then be 3¾d. and 1¼d. per unit, or 1s. 8d. per annum per 8-c.p. lamp fixed + 1¼d. per unit supplied. If a uniform rate per unit is adopted, it must be different for different classes of consumers, according to their probable hours of use. A comparison of the charges in various towns on the maximum demand system is given, with a diagram, and the paper ends with a number of tables.

In the discussion **H. A. Mavor** pointed out that in private installations distribution costs are absent, and labour charges less than in central stations, and **E. G. Tidd** considered the depreciation rates too high. In reply, **W. W. Lackie** said that in a central station only half as much plant need be installed as would be required in an isolated installation. A. H. A.

REFERENCES.

1606. *Drop in Alternate Current Mains.* **L. Fleischmann.** (Elektrotechn. Zeitschr. 21. p. 255, March 29, 1900.)—A short paper in which the author develops analytically expressions for the drop of potential along alternating-current mains, when transmitting power to an inductive load of given power-factor. A. H.

1607. *Accumulators for Motor Cars.* **E. C. Rimington.** (Automotor Journal, 4. pp. 108–109, Dec., 1899 ; pp. 141–142, Jan., 216–218, Feb., 253–254, March, 1900.)

1608. *French Electric Tramways.* (Ind. Élect. 9. pp. 113–120, March 25, 1900.)—This article contains a table giving particulars about the various electric tramways and railways in France.

1609. *Central Electric Supply Company.* (Elect. Engin. 25. pp. 559–561, April 20, 1900.)—An abstract of the specification prepared by Kennedy for work in connection with the above Company.

1610. *Overhead Line Construction.* **A. B. Herrick.** (Street Rly. Journ. 16. pp. 235–236, March, 1900.) [See also Abstract No. 786 (1900).]

1611. *Construction of Overhead Equipments.* (Elect. Rev. 46. pp. 303–304, Feb. 23, 341–342, March 2, 430–431, March 16, and 598–599, April 6, 1900.)—A series of articles dealing with the various details from the practical point of view.

1612. *Zurich Electric Tramways.* **J. S. Edström.** (Elektrotechn. Zeitschr. 21. pp. 323–328, April 26, 1900.)—A detailed description of the Zurich tramways. Eleven illustrations are given of the generating plant, various forms of rail bonds, feeder boxes, the cars, and controller arrangements, &c. E. K. S.

1613. *American Types of Automobiles.* (Elect. World and Engineer, 35. pp. 427–430, March 24, 1900.)—Detailed account of Riker motor cars. [See also Abstract No. 1220 (1900).]

TELEGRAPHY AND TELEPHONY.

1614. *Wireless Telegraph Experiments.* **Tissot.** (Soc. Franç. Phys., Bull. 141. p. 2. Jan. 5, 1900.)—With Ducretet's apparatus the author communicated over a distance of 42 km. Good results were obtained with a simple oscillator. The earth connection is imperative, but a capacity at the top of a tall wire is useless. There is no simple law between the height of the wire and the distance. Atmospheric effects are avoided by earthing the tall wire through an inductive coil and placing a capacity between the wire and coherer. M. O'G.

1615. *Wireless Telegraphy.* **R. A. Fessenden** and others. (Amer. Inst. Elect. Engin., Trans. 16. Discussion, pp. 635–678, 1899.)—This was a desultory discussion covering generally the ground that had been already traversed in the development of wireless telegraphy. New results were confined to the communication of **Fessenden,** who described apparatus he had devised to give *proportional* indications of electric oscillations at a distance. The ordinary coherer either acts or does not act—it is not a quantitative indicator. Three forms of instrument are described by Fessenden. The simplest consists of two coils connected in series with the receiving wire and with one another. Between them is suspended a closed ring carrying a mirror and suspended by a quartz fibre. An alternating field is set up in the coils on the reception of an impulse, and the closed ring is repelled, the mirror reflecting a beam of light. The deflections of the beam are proportional to the strength of the impulses emitted by the sender. This worked satisfactorily up to a distance of five miles. The second form of the apparatus is a modification of this arrangement in combination with a telephone receiver and transmitter. The third form is a coil in series with the collecting wire; through this runs an iron wire with its ends brought close together to form an air-gap in a magnetic field; a bent, closed ring supported like that used in the first-mentioned apparatus is deflected by the alternating magnetic field so formed when an impulse is received.

The rest of the discussion dealt with *proposals.* R. N. L.

1616. *Wireless Telegraphy Station at Wimereux.* **G. Ferrié** and **J. Boulanger.** (Écl. Électr. 22. pp. 507–515, March 31, 1900; Revue du Génie Militaire, t. xviii. pp. 230 and 437, 1899.)—A good general and scientific description of the above station, and up to date. The points of special interest are connected with the various methods from time to time adopted by Marconi for attempting to secure syntony between two stations. The first of these consists in varying the capacity of the aerial conductor by suspending two earthed metallic bands attached to the spar from which the former is suspended at a point slightly behind its point of suspension. The capacity is diminished or increased by approaching or withdrawing these metallic bands from the vertical conductor. By giving two distant vertical conductors in this way the same capacity, a certain amount of syntony is produced between them. Another method (described in a note) consists in connecting the vertical (or aerial) conductor to earth through the primary of an induction coil. The coherer is arranged in the secondary circuit in series with a condenser. It is suggested that the capacity and self-induction thus obtained

enable syntonisation to be effected by varying their values. Another rôle played by this arrangement is that of an automatic discharger for the atmospheric electricity collected by the aerial conductor which escapes through the primary of the induction coil. A third method used in conjunction with the metallic bands above described is to vary the self-induction of the aerial conductor by rolling up some of the lower end of it (which is of course insulated) on 4 mm. ebonite cylinders. The actual apparatus used by Marconi, if differing from these methods, is not known, as he has it fixed up inside a sealed box and calls it a "jigger." An interesting fact in connection with the syntonisation experiments is that two stations, although desyntonised with one another, must not be closer together than 2,500 metres or they will interfere with one another. R. N. L.

1617. *Magnetised Coherer.* **C. Tissot.** (Comptes Rendus, 130. pp. 902–903, April 2, 1900.)—In the course of some experiments in wireless telegraphy made between Brest and Ushant, the author hit upon a device which considerably increases the sensitiveness of the steel or nickel coherer used, and at the same time makes it work with greater regularity and certainty. The device consists in placing the coherer in a magnetic field, whose lines of force are parallel to the axis of the tube. The latter should contain some kind of magnetic filings—steel, nickel, or cobalt. The electrodes should preferably be non-magnetic. The tube is placed between the pole-pieces of an electromagnet feebly excited, and the current transversing the coherer should also be feeble, so as not to interfere with the decohering action. The magnetisation of the coherer allows of the distance between the electrodes being increased five or six times. The sensitiveness is easily regulated by changing the strength of the magnetic field. When the field is suddenly annulled, the slightest shock suffices to decohere the instrument. The author, therefore, hopes to work the magnet by a relay, and thus to secure automatic decoherence. E. E. F.

1618. *Telegraph Steamer, "Von Podbielski."* **Jamieson.** (Elect. Rev. 46. pp. 728–729, May 4; 771–772, May 11, and 863–864, May 25, 1900.)—The author describes the general arrangements, engines, boilers, cabling machinery, tanks, and testing-room of a new steamer for a German firm of Cologne. The forward cable-drums have the brakes on the outside peripheries, being themselves internally geared. The brake screws are worked by means of worm gearing for fine adjustment. Johnson and Phillips have fitted the brakes with adjusting nuts, which enables them (after being regulated for any desired tension) to be released as often as may be necessary, and reapplied without the possibility of increasing the tension beyond the desired amount. The brake blocks are made of selected elm-wood, securely attached to steel straps. Each brake band has a water service pipe fixed to its periphery, with nozzles at intervals to distribute the water around the drum during working. The bands are suspended on springs, so that when released they will leave the drums equally and simultaneously all round. The springs are adjustable, so as to allow for a reasonable wear of the wooden blocks. The brake pulleys of the after paying-out machines run in water-tanks, to keep them cool. The bands are similar to those of the forward machines, but they are fitted with weighted levers, which is the general practice. Instead, however, of the weights being made always to act at the same leverage, and the brake power altered by adding or deducting weights, the positions of the weights are adjustable along the

brake levers by means of a hand wheel and screw, so that the tension on the cable may be varied through a considerable range without adding or deducting any weights. The two brakes can be released bodily by means of a hand wheel and worm gear, and they can also be adjusted, so that both act simultaneously or otherwise.

The dynamometer of Johnson and Phillips consists of a sheave with a carrier sliding on a central cylindrical tubular column: this column acts as a dash-pot by having a piston working inside thereof in oil or soapy water. In addition there is a spring placed inside the column which comes into action during the lighter tensions on the cable, so that as the spring is compressed the moving weight is correspondingly lessened. This enables a greater scale range throughout the lower stresses, and the corresponding scale readings are, therefore, not directly determined by the usual dynamometer formula, but by actual trial. E. O. W.

1619. *Selective Signal and Privacy Switch for Party-Line Telephones.* **H. S. Webb.** (Amer. Electn. 12. pp. 139–141, March, 1900.)—The author describes a method by Barrett whereby six subscribers may be connected on the same pair of wires and the ground circuit as before. Means are provided for preventing cutting-in and overhearing. The six subscribers comprise three groups of two each, two stations in each group being similar but called up by currents of opposite polarity. There are eight keys in the exchange, the first six for selectively calling any one of the six subscribers, the seventh for restoring the connection of the receivers at all six stations on the line, and the eighth for disconnecting or barring all telephone receivers from the line. Supposing the two lines to be denominated A and B, a positive current from the Exchange, returning through earth, will ring up station 1, the other being unaffected; a negative current in the same circuit will ring up station 2; similarly positive and negative currents through line B and to earth, will ring up stations 3 and 4 respectively; finally a positive current through A returning through B or *vice versâ* will ring up stations 5 and 6 respectively. At the exchange the first step in calling is to depress the eighth key and send negative currents over A and B to earth at every station by which all the receivers are, by the peculiar winding of electromagnets and arrangements of armatures, locked out, and "engaged" annunicators displayed. Then the operator rings the desired station by depressing the appropriate key. When conversation is finished the seventh key is operated at the exchange, sending a positive current over both lines to earth at all stations, thereby connecting again all the receivers to the line, and again concealing the "engaged" annunicators. To call up the central exchange the subscriber merely takes down his receiver. In doing so the hook switch momentarily connects line A to earth, which affects a differentially wound annunicator at the exchange. The connections and windings are fully illustrated in the article. E. O. W.

REFERENCE.

1620. *Type-printing Instruments.* **Raps.** (Elektrotechn. Zeitschr. 21. pp. 296–300, April 12, 1900.)

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

AUGUST 1900.

GENERAL PHYSICS.

1621. *Automatic Sprengel Pump.* **W. Donle.** (Zeitschr. Instrumentenk. 20. pp. 78–82, March, 1900.)—This paper describes a form of Sprengel vacuum pump with one fall-tube in which the mercury is raised again to the high level by means of an ordinary aspirator. In order to raise the mercury through the necessary height, which is greater than the barometric height, it is sucked up by the aspirator at a greater rate than it is supplied by the fall-tube, thus making the mercury column in the suction-tube a broken one, with bubbles of air between the mercury threads similar to the column in the fall-tube. J. B. H.

1622. *Pendulum with Constant Electric Control.* **C. Féry.** (Comptes Rendus, 130. pp. 1248–1250, May 7, 1900.)—The pendulum is kept in regular motion by means of a special transformer that gives induced currents, which carry a quantity of electricity independent of the battery, and which can be regulated at will. G. E. A.

1623. *Hardness of Elements.* **J. R. Rydberg.** (Zeitschr. Phys. Chem. 33. pp. 353–359, May 2, 1900.)—The author has collected and compared all available information as to the hardness of the elements, and expresses the results, according to Mohs' scale, in the form of a table and curves. The hardness, like many other physical properties of the elements, is shown to be a periodic function of the atomic weight. N. L.

1624. *Relative Effusion of Argon, Helium, and other Gases.* **F. G. Donnan.** (Phil. Mag. 49. pp. 423–446, May, 1900. Paper read before the Physical Society of London.)—This paper gives the results of an experimental investigation of the relative effusions of argon, helium, and other gases. The gases passed from one vessel into another, previously evacuated, through a very small hole, and the time taken for the pressure in the receiving vessel to rise from zero to a certain amount was measured. The paper begins with a discussion of the mathematical treatment of the subject, and then describes the apparatus used in the investigation; but for this as well as for an account of the difficulties met with in the investigation, reference must be made to the paper.

The results are as follows :—

1. Argon is found to effuse, when compared with oxygen, $3\frac{1}{2}$ per cent. faster than as calculated by the law of the inverse square root of the density. This result is independent of any masking effect due to viscosity.

2. This result is, further, in qualitative agreement with the adiabatic theory of the efflux of ideal gases, and is, if this may be granted, a confirmation of the high specific-heat ratio of argon.

3. When viscosity-effects are eliminated or allowed for, it is found that hydrogen, oxygen, and carbon monoxide effuse relatively in the manner predicted by the theory for ideal gases possessing the same, or nearly the same, specific-heat ratio.

4. Carbon dioxide, when compared with oxygen, appears to effuse about 1 per cent. *faster* than as calculated from the densities. This result is not in accordance with the adiabatic theory of the efflux of *ideal* gases.

5. The results obtained for helium are not uniform, and are affected by a viscosity-correction depending on an empirical formula. They are sufficient, however, to show that the behaviour of helium is unlike that of argon—a result which is not foreseen by the theory.

6. If account be taken of the deviation of ordinary gases from the ideal laws, it is possible to obtain an expression for the efflux which contains a correction-term involving the constant K of the Thomson-Joule effect.

7. The sign of this correction-term shows that a real gas will effuse more *rapidly* or more *slowly* than an ideal gas of equal density and specific-heat ratio, according as K is *positive* or *negative*.

8. The suggestion is made that possibly the anomalous results obtained with carbon dioxide and helium may be thus explained. The deviations of the observed results from the results calculated for an ideal gas are, in the case of CO_2, in *qualitative* accordance with the theory proposed. In the case of helium they would be so if that gas possessed a negative K. J. B. H.

1625. *Temperature of the Acetylene Flame.* **E. L. Nichols.** (Phys. Rev. 10. pp. 234–252, April, 1900. Paper read before the American Physical Society, Feb. 24, 1900.)—The author gives the results of experiments made to determine the temperatures at different points of an acetylene flame, for which various observers have given widely different numbers; thus Le Chatelier gave 2,100–2,420°, whilst Lewes found a maximum temperature of 1517°, Smithell's values being intermediate between these two. The flame employed by the author is of the usual flat type, the burner being capable of lateral motion by means of a micrometer screw. The thermo-electric couples are composed of platinum and platinum-rhodium (10 per cent.) wires, of thickness varying from 0·01996 to 0·00821 cm.; the ends of the wires are pinched together in the form of a **V**, the point of which is fused by plunging into an oxy-hydrogen flame, and then cut off so as to leave a connection about 0·005 cm. thick. The E.M.F. produced at the heated junction is measured by a potentiometer and Clark cell. To observe the acetylene flame, and to measure the distance between its median plane and the thermo-element, a magnified image is obtained on the ground glass of a micro-camera, the plane of the flame being arranged parallel to the axis of the camera. The thermo-junction is placed at a distance of 6 mm. from the median plane, and the temperature taken by balancing the potentiometer, the junction then being gradually brought up to the middle of the flame, the temperature at each new position being determined. With each of the four couples used, the temperature is found to increase gradually at first, but at a distance of about 0·4 cm. from the

middle the curve suddenly becomes steep, so that this distance probably measures the thickness of the layer of non-luminous gas surrounding the well-defined luminous layer, which has a thickness of about 0·065 cm. Before this luminous layer is reached, the temperature curve shows signs of approaching a maximum, the thicker junctions (0·01996 and 0·01598 cm. diameter) being coated with carbon and considerably cooled when coming into contact with the luminous region. The thinner couples give temperature curves lying above those of the thicker ones, and give no deposit of carbon, but are melted in the middle portion of the flame, one of them after passing the median plane and the other before that plane is reached. By extrapolation the temperatures at various parts of the flame for a thermo-junction of negligible cross-section can be estimated ; by this means the temperature at the middle of the flame is found to be 1,900°, whilst at 1 mm. from the middle the value is 1,920°. Similar experiments with a luminous coal-gas flame indicate its highest temperature to be 1,780°, the value for a candle flame being 1,670°. The fact that a thin platinum wire—prepared by Wollaston's method of silver-plating it, then repeatedly drawing through a die to diminish its diameter and finally dissolving away the silver—can be melted in a candle flame, the author shows is due to the presence of impurities in the wire which make it melt at 1,674°, whilst pure platinum melts at 1,775°. The temperatures given by the author are based on an arbitrary scale in which the melting-point of platinum is taken as 1,775°, and that of gold as 1,070°. T. H. P.

1626. *Vertical Electric Seismoscope.* **G. Agamennone.** (Accad. Lincei, Atti, 9. pp. 204–210, March 18, 1900.)—A strong upright brass column carries at the top a cross-piece supporting three spiral springs, which hang vertically down. The two outer ones support a lead weight of about 1 kilogramme, to the centre of which is attached a platinum point. The middle spring is weighted with a less weight, and while the former oscillates about twice per second, the latter oscillates two or three times more rapidly. The smaller weight carries another spring supporting a third weight in the shape of a flat brass cylinder, which oscillates still more rapidly. Its lower surface is gilt, and just touches the platinum point attached to the largest weight. The instrument is prepared for use by adjusting the springs so that the platinum point is at a certain slight distance below the reflecting surface, the adjustment being aided by the image of the point in the surface. The point and the surface are connected to the two terminals of a chronograph circuit.

The author also describes an instrument which is a combination of the above and his older instrument for the registration of horizontal wave motions. He claims that both are cheap and efficient. E. E. F.

1627. *Capillarity.* **G. Bakker.** (Zeitschr. Phys. Chem. 33. pp. 477–499, May 18, 1900.)—The author maintains that the proofs of Jurin's law usually given are incorrect, in that they treat of thermal pressure and cohesion as additive quantities, whereas he maintains that they are different in character ; as he expresses it, the field of action of the one is a surface, of the other a space. And this difference in character, and not merely the change of form in the surface of the liquid, he holds to be the cause of the observed phenomena.

Referring to Neumann's investigations, in which the principle of virtual displacements is applied, he holds that in the equations $\frac{du}{dx}+\rho\frac{dv}{dx}=0$, &c., where v denotes potential, and ρ the density, u is not the hydrostatic, but the

thermal pressure. He then shows by considerations regarding the surface tension that within the capillary layer the hydrostatic pressure is a vector and not a scalar.

He then investigates the potential function of capillarity. To this end we have choice of two methods, namely, to construct a homogeneous medium which shall present the same force-phenomena as the liquid, or, secondly, to regard the liquid as an assemblage of moving particles under dynamical laws. He chooses the former method, and assumes that at every point in the medium not within the capillary layer, the resultant force, not merely is on the average, but is always, zero, so that if ψ be the potential, $\frac{d\psi}{dx}=\frac{d\psi}{dy}=\frac{d\psi}{dz}=0$, from which data he obtains $\psi=-f\epsilon^{-qr}/r$, where f and q are constants. Also q is the reciprocal of a line, say, $fq=\frac{1}{\lambda}$. It is then shown that any solution of the equation

$$\nabla^2\psi=q^2\psi+4\pi f\rho$$

is unique.

The energy per unit of volume assumes the form

$$W=-\frac{1}{4\pi f}(R^2+\frac{\psi^2}{\lambda^2})$$

where R is the force derived from ψ. This is reduced to the Newtonian form by making λ infinite, or $\psi=-\frac{f}{r}$. The capillary surface tension is then discussed and the molecular pressure, and a value is obtained for Laplace's function H. In conclusion he finds that the capillary surface tension is connected with a difference between the forces acting parallel and perpendicular to the surface of the capillary layer. S. H. B.

1628. *Telescopic Planets.* **C. de Freycinet.** (Comptes Rendus, 130. pp. 1145–1154, April 30, 1900.)—The author analytically examines the conditions following the breaking up of the primary sun in the centre of our system, which gave rise to the swarm of asteroids, or minor planets, now revolving between Mars and Jupiter. He discredits the idea that the whole of these bodies originated from a single ring thrown off from the central body, and by examining the elements of their orbits has been enabled to classify them into groups, the members of each group being related closely by their elements. He therefore concludes that these small planets have been formed by the successive detachment of spherical layers from the central sun, each having its own rate of rotation, &c. He then divides the 428 planets at present known into three groups, according to the mean inclination of their orbits, and finds that the mean distance from the sun and the eccentricity both vary so regularly as to be noticeable. Thus—

Inclination of Orbit.	Eccentricity.	Mean Distance.	No. of Planets.
0° – 10°	0·1332	2·757	237
10° – 20°	0·1574	2·771	162
20° – 30°	0·2042	2·813	28

C. P. B.

LIGHT.

1629. *Standards of Light.* **J. E. Petavel.** (Roy. Soc., Proc. 65. pp. 469–503, Jan., 1900.)—Various classes of standards of light are described by the author which belong to the two main divisions: (1) Flame standards, and (2) Incandescent standards. He considers at some length the arc light standard, and concludes that the intrinsic brilliancy of the crater of a silent arc is about 147 c.p. per sq. mm.; and that even when the most favourable conditions are selected, and the intensity of current and the length of the arc are maintained constant, it is difficult to obtain consistent results, variations of over 5 per cent. being by no means unfrequent. The crater of the arc does not, therefore, possess the qualities required of a standard. Incidentally the experiments made confirm the theory that the crater of the arc is at the temperature of volatilisation of carbon.

The author next describes and considers the Lummer and Kurlbaum incandescent platinum standard, and then gives an account of researches on the molten platinum standard of light. The methods of fusing platinum by the electric current, and by the oxy-hydrogen blowpipe, are described. To ensure suitable conditions and a pure surface (1) the platinum must be chemically pure, (2) the crucible must be made of pure lime, (3) the hydrogen burned must contain no hydrocarbons, and (4) the gases should be burnt in the ratio of four volumes of hydrogen to three of oxygen. A large number of observations extending over a long period of time were made. It was found that the effect of contaminating the platinum with either silica or carbon was very marked. From the results of his work the author states that the probable variation in the light emitted by molten platinum under standard conditions is not above 1 per cent., and the accuracy of this standard is capable of being increased. Physiological considerations fix a limit to the accuracy of photometric observations. It is not impossible that the accuracy of the platinum standard may attain to or even surpass this limit. J. J. S.

1630. *Alteration of Surface Properties of Metals by Light.* **H. Buisson.** (Comptes Rendus, 130. pp. 1298–1300, May 14, 1900.)—Sunlight causes a diminution in rapidity of discharge from an amalgamated zinc plate, and this effect is not permanent. The potential of a plate also varies under the action of sunlight. A large number of metals become more negative after illumination, but platinum becomes more positive. A plate is found, in general, to have two definite potentials in darkness and in light, and there is an inversion wave-length, such that more refrangible waves cause a negative variation of potential, less refrangible a positive variation. For zinc this wave-length is 0·310 μ. G. E. A

1631. *Optical Illusions.* **A. Wyczółkowska.** (Acad. Sci. Cracovie, Bull. 1. pp. 7–23, Jan., 1900.)—The paper treats of the optical inversion observed in perspective drawings as of hollow cones, &c., and experiments show: (1) That the maximum speed of inversion is about that of the observer's pulse, but is no function of it. (2) The inversion of plane figures is accompanied by a change in refraction of the eye, as proved by means of an ophthalmometer. (3) That there is an inversion between the real and the illusory image

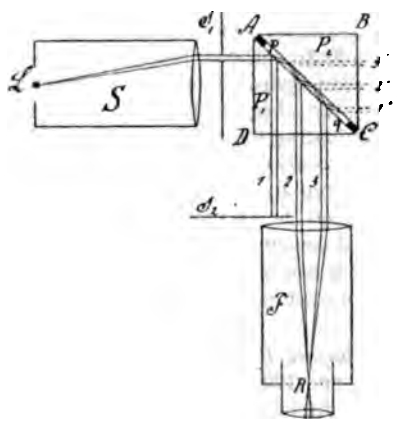
as shown by solids, and there is also an inversion from one illusory image to another as shown by plane figures. (4) The inversion in solids is accompanied by four distinct phenomena, viz.: (i) Changing of the intensity of the light, tone, colour, and form of the object observed; (ii) the duration of the image; (iii) the movement of the image; and (iv) the inclination of the image; this latter being a function of the angle at which the eye observes the object. An explanation of the cause of inversion is given.

G. E. A.

1632. *Complementary Interference Fringes.* **O. Lummer.** (Preuss. Akad. Wiss. Berlin, S.ber. 24. pp. 504–513, May 3, 1900.)—If one looks at a bright surface through two right-angled prisms placed with their hypothenuses together, but separated by a thin film of air, and if the eye is focused for parallel rays, one sees a system of interference fringes parallel to the line bounding the area of total reflection. The present paper contains a study of these fringes, and the author has discovered that in reflected light two systems of fringes are obtained, one system being the complementary of the other.

The method of experimenting is seen in the diagram. The double prism BD is mounted on the table of a goniometer, of which S is the collimator

Fig. 1.



and F the telescope, both focussed for parallel rays. The slit is illuminated by an Aron's mercury lamp. S_1 is a slit diaphragm, and S_2 a screen with which any number of the reflected beams 1, 2, 3, &c., may be cut off. If S_2 is absent, then the field to the right of R appears brightly illuminated by the totally-reflected light of the lamp, and to the left of R the interference minima appear on a blue white ground, the fringes being coloured from the different wave-lengths present in the mercury light. If S_2 is now placed so as to cut off the beams 1 and 2 the field changes to the complementary; the field to the right of R appears dark, while to the left of R on a dark ground bright interference maxima appear.

The theory of the phenomena is fully explained in the paper. J. B. H.

1633. *Spherical Aberration in Double Achromatic Objectives.* **W. Harkness.** (Amer. Journ. Sci. 9. pp. 287–291, April, 1900. Paper read before the Philosophical Society of Washington in a slightly different form, Oct. 28,

1898.)—The main part of this paper is devoted to proving that in any thin lens, if the spherical aberration is completely corrected for all objects situated in the axis of the lens, then the oblique aberration will also be completely corrected.

The problem of obtaining equally good definition all over the field of view is thus reduced to the problem of making the destruction of spherical aberration for axial rays independent of the distance of the radiant from the telescope. This problem was solved by Herschel in 1821, so that objectives made according to his rules will give good definition throughout a wider angle than any other double achromatic objective. J. B. H.

1634. *Anisotropic Prisms.* **C. Viola.** (Accad. Lincei, Atti, 9. pp. 196–204, March 18, 1900.)—The author deals with prisms made of uniaxial or biaxial crystals obeying Fresnel's laws. He decomposes the total deviation of the incident beam into two components, termed the longitudinal and the lateral deviations respectively, and proves the following theorems: (1) The minimum deviations for a given value of the azimuth occur in the case of a plane wave parallel to the first bisectrix of the prism. (2) The lateral deviation is zero when the plane wave is parallel to the first bisectrix or to the edge of the prism. (3) When the plane wave is parallel to the edge of the prism the minimum deviation is the absolute analytical minimum of all the deviations possible in an isotropic prism. (4) The wave plane parallel to the first bisectrix of the prism gives a minimum deviation when it is normal to a plane of symmetry of the crystal. (5) In such a case the lateral deviation is zero, as in the case when the wave plane is parallel to the edge of the prism. Theorems (4) and (5) offer a new and simplified method for determining the indices of refraction of a bi-refracting prism. For when the lateral deviation is zero the minimum deviation and the azimuth are sufficient to determine the principal index of refraction. E. E. F.

1635. *Formulæ for Lenses.* **L. Pfaundler.** (Akad. Wiss. Wien, S.ber. 108. pp. 477–489, 1899.)—This paper contains a criticism of the nomenclature with regard to lenses which was first introduced by Gauss, and is now in general use. The criticism applies particularly to the terms "convergent" and "divergent." For very thick lenses this nomenclature is misleading, and the author in this paper investigates all the possible cases. He shows that a lens is convergent or divergent not according as the second focal length is positive or negative (Gauss), but according as the distance between the second focus and the second surface (Schnittweite) is positive or negative, and he advocates the division of lenses into positive and negative accordingly. A lens is best represented by its radii of curvature, and these he calls + or − according as the centre of curvature is in the direction of motion of the light or the reverse. A lens may be completely represented, then, by two pluses or two minuses or one plus and one minus, the two signs being separated by a sign of equality, greater than, or less than, according as the first radius is equal to, greater or less than the second. J. B. H.

1636. *Crystalpolymeter for the Examination of Crystals.* **C. Klein.** (Preuss. Akad. Wiss. Berlin, S.ber. 18. pp. 248–257, March 29, 1900.)—The author gives a description of the construction and method of working of a new three-circle goniometer, which can be used for the following determinations: (1) Crystal angles. (2) Refractive indices by means of prisms, of solids, and (3) of liquids. (4) Refractive indices of solids by total reflection in liquids.

(5) Examination of crystals in equally refrangible media for (*a*) determining the position of the axis and axial angle and measuring the latter, and (*b*) fixing the positions of extinction for the faces of a zone. (6) Investigation of thin and thick plates in parallel and in convergent polarised light. T. H. P.

1637. *Telemicroscope.* **A. Deschamps.** (Comptes Rendus, 130. pp. 1176–1177, April 30, 1900.)—This is an instrument which enlarges by about 12 diameters objects placed at a distance of some 25 cm. It thus enables the observer to study insects without disturbing them from their normal surroundings. The instrument consists of two Dollond achromatic lenses separated by a distance less than the focal length of the most converging lens. These form the objective. The eyepiece is a lens of short focus, chosen so as to give the maximum enlargement and field. The depth of focus of the instrument is very great, and it gives effects of relief similar to stereoscopic effects. No detailed description is given. E. E. F.

1638. *Artificial Colour-blindness and Successive Contrast.* **G. J. Burch.** (Roy. Soc., Proc. 66. pp. 204–216, April, 1900.)—The author's observations on artificial colour-blindness seem unfavourable to the theory of Hering and favourable to that of Young. An account is first given of opinions held on this subject before the time of Young. There were two groups of opinions in the eighteenth century. One school held that after the stimulus of a strong light of any given colour a species of reaction sets in, and the sense of the supplementary colour is produced. The other school, from which the theory of Young developed, seems to have been founded by Scherffer, who suggested that a continuous action of, for instance, red light, may so change the order and arrangement of the parts of the back of the eye that those rays which are peculiarly fitted to act upon that particular part may be no longer strong enough to communicate to those parts the necessary vibratory movement until a little rest shall have restored them to their condition, and during this time the other rays of different kinds will not cease to act. A description is next given by the author of the present paper of his experimental investigation of the phenomena of successive contrast. This is an effect of two stimuli—a primary stimulus by which the retina is fatigued, and a secondary stimulus, the effect of which is modified in consequence of the first. The colour-sensations excited may be reduced to four at the most. To arrive at the fundamental laws of contrast the conditions may be varied as follows: Let the first stimulus excite a colour-sensation, taking each in turn or separated from the rest as in the spectrum. Four cases arise:—

(1) The second stimulus may excite all the sensations, *i.e.*, it may consist of white light. This gives the complementary colour, *i.e.*, the direct spectrum, as R. W. Darwin calls it, of all the colours save that excited by the first stimulus.

(2) The second stimulus may excite the same sensation as the first, but less strongly. This gives a black after-image.

(3) The second stimulus may excite two or more colour-sensations including that of the first stimulus. The colour of the resulting image is that of the second stimulus *minus* the first.

(4) The second stimulus may excite one or more sensations, none of which were included in the first stimulus. The colour of the resulting image is that of the second stimulus *plus* the admixture, usually small, of the first.

Experiments illustrating the above cases are described, which include the following:—

1. After fatiguing the retina by the spectrum, a uniform white light is observed. This is done most readily by means of a low-power spectroscope with a reflected-scale tube.

2. After fatiguing the retina by the spectrum, a less intense spectrum is observed. The effect upon the retina of light of any wave-length is to blind the eye temporarily for light of that same wave-length.

3. After fatiguing the retina by any one colour, the entire spectrum is observed. A very transient colour-blindness is here produced.

After giving the details of the above experiments, contrast phenomena by intermittent stimulation are mentioned, and an account is given of the experiments of S. Exner and Shelford Bidwell, which have been repeated and continued by the author of this paper. J. J. S.

1639. *Artificial Colour-blindness.* **G. J. Burch.** (Roy. Soc., Proc. 66. pp. 216–219, April, 1900.)—The author wishes to guard against the supposition that the results described by him (Phil. Trans. B. vol. 191, 1899) are phenomena of a pathological condition induced by severe strain in the structure of the eye. The same phenomena occur with the faintest light the eye is capable of perceiving. The following experiments illustrate this statement :—

1. The observer's left eye was exposed to direct moonlight in the focus of a lens behind a screen of ruby glass combined with a gelatine film stained with magenta. After three minutes the observer looked through a spectroscope directed to the moon. The red had entirely disappeared, and only the green, blue, and violet were visible. With the right eye the red as well as the other colours were visible.

2. A similar result was found when a green glass screen instead of a red was employed, the right eye being exposed in this case. The green sensation disappeared. The left eye was still partially red-blind, and the contrast between the spectrum as seen by it and by the right eye was very marked. Merely to look for a few seconds at a scarlet poppy in a corn-field causes a measurable degree of red-blindness for the next two or three minutes, and similar production of temporary green-blindness is observed in the case of persons who have been walking for a time in grass fields. J. J. S.

1640. *Theory of the Welsbach Burner.* **W. Nernst** and **E. Bose.** (Phys. Zeitschr. 1. pp. 289–291, March 31, 1900.)—That the temperature of a platinum wire when brought into a Bunsen flame is the higher the finer the wire, is not due to conduction, as shown by the fact that coils of thick platinum wire have the same low luminosity as simple loops. The temperature attained by the foreign body is the higher the quicker the heat is supplied to it, and the less the heat radiated by it. Carbon particles obey the laws of radiation of black bodies, and therefore emit infra-red heat rays to a great extent. A substance whose radiation was confined to the visible spectrum would be the ideal incandescent substance. It is probable that magnesium closely approaches this ideal state. The mantle of the Welsbach (Auer) burner also comes near it. By tracing the luminosity of the spectrum in terms of a normal incandescent lamp, and drawing the luminosity curves for incandescent lamps at various efficiencies and for the arc, a series of curves may be obtained which represent the radiation of carbon at various temperatures. The curve of the Welsbach burner shows a considerable falling off in the red portion, and, therefore, probably also in the infra-red region, when compared with the radiation of carbon. This means that much of the energy

otherwise wasted in heat is utilised for increasing the luminosity, and this fact, together with the rapid acquisition of the temperature of the flame, accounts for the economy of the Welsbach incandescent light. E. E. F.

1641. *Phenomena of Polarised Light.* **N. Umow.** (Ann. d. Physik, 2. 1. pp. 72–77, May, 1900. From the Zeitschr. Phys. Chem. 30. p. 711, 1899.)—If a solid whose surface consists of a number of reflecting surfaces is placed in the path of a parallel beam of plane-polarised rays, the light reflected by it will in general fill a space of a pyramidal shape, with varying intensity. The minimum intensity will occur at those medial planes which contain the direction of vibration and the normal of the reflecting surface. This minimum will depend upon the size of the angle of polarisation at the limit of the body and the surrounding medium. In this manner colour phenomena can also be produced. Turbid media containing very small reflecting bodies suspended in them will show different colours in different directions. Such a suspended particle therefore plays the part of an analyser. The author describes an apparatus based upon these considerations, and suitable for the objective presentation of the general phenomena of polarised light. An electric lamp is furnished with a Foucault prism provided with a diaphragm with circular perforation. The image of the aperture is projected to a distance by means of a lens, and various substances are introduced into the path of the rays. A glass cone turned with its apex towards the source, and having its base in the focal plane, shows on a screen in the same plane a ring-shaped luminosity traversed by a black diameter. It thus acts as an analyser. A quartz-plate suitably cut gives a brightly-coloured pattern. A Babinet compensator gives coloured curves. If a quartz plate is introduced, and the beam is reflected downwards into a long vessel filled with a solution of cane sugar containing a few drops of an alcoholic solution of colophony, a spiral coloured beam is obtained, exhibiting the phenomenon of circular polarisation. As the beam descends, the colours become less vivid, owing to overlapping and absorption. E. E. F.

1642. *Conditions of the Stability of Optical Activity.* **J. A. Le Bel.** (Comptes Rendus, 130. pp. 1552–1555, June 5, 1900.)—The fact that certain asymmetric carbon and nitrogen compounds have not been obtained in an optically active form is explained by the instability of the latter and its consequent transformation into the enantiomorphic isomeride, this going on until complete racemisation takes place. The stability of such active molecules depends on the closeness of the contact existing between the separate radicles, and should hence be increased by an increase in the strength of the attraction exerted by the central atom on the different radicles, and also by an increase in the volume of the radicles. Thus for molecules like that of lactic acid in which the radicles are relatively small, the rotatory power readily disappears, whilst valerianic acid racemises with far less ease. On heating active amyl alcohol for forty-eight hours in sealed tubes, the author finds that the optical rotation decreases as the temperature rises; before heating, the rotation in a 22 cm. tube is $-8° 19'$, and after heating at 50°, $-8° 1'$; at 100°, $-4° 8'$; at 150°, $-0° 47'$; whilst after heating at 200° the alcohol becomes inactive. The tetra-substituted ammonium chloride, $NH(CH_3)(C_2H_5)(C_3H_7)Cl$, could not be obtained in an active form, but this is found to be possible with the compound, $N(CH_3)(C_2H_5)(C_3H_7)(C_4H_9)Cl$, and on heating at 50° a solution giving in a 50 cm. tube an initial rotation of $-2° 33'$, the rotation decreases to $-2° 28'$, whilst at 100° it becomes $-2° 20'$; at higher temperatures the liquid becomes coloured. T. H. P.

1643. *New Analyser for Saccharimeter.* **F. F. Martens.** (Zeitschr. Instrumentenk. 20. pp. 82–85, March, 1900.)—This analyser, or instrument for measuring the rotation of the plane of polarisation, consists of two quartz wedges of equal angle, one right-handed and the other left-handed. These are turned with their two thick edges in the same direction and with the two outside faces parallel. Between the wedges is placed a glass wedge or prism, of such an angle that the deviation of a ray on passing through the glass equals the sum of the deviations in the two quartz wedges. The glass wedge is placed so that it deviates the ray to the opposite side from the quartz wedges and makes the total deviation zero. If a ray passes through equally thick parts of the right-handed and left-handed wedges no rotation will result, but if one wedge is moved relatively to the other a greater thickness of right-handed or of left-handed will result, and the corresponding rotation will be produced. The motions of the wedges are read off on scales. The analyser eyepiece contains the ordinary Nichol prism. The advantage of the arrangement is that the beam has the same rotation all over the field of view. J. B. H.

1644. *Prism of Uniform Dispersion.* **C. G. Abbot** and **F. E. Fowle, Jr.** (Astrophys. Journ. 11. pp. 135–139, March, 1900.)—The authors describe an arrangement in which prisms of different dispersions and different angles are combined in such a way as to give a spectrum in which equal increments of deviation correspond approximately to equal increments of wave-length. J. J. S.

1645. *Colour Photometer.* **F. F. Martens.** (Phys. Zeitschr. 1. pp. 182–183, Jan. 13, 1900. Read before the 71st Naturforscherversammlung in Munich.)—This is a spectro-photometer designed for comparing the absorptions of different solutions for the different lines of the spectrum. An ordinary spectroscope is used, and, in front of the slit, a compound prism similar to that used in the Lummer-Brodhun photometer is placed. One-half of the common hypothenuse-face of the two prisms is silvered, and the combination is placed in front of the slit so that one-half of the slit is illuminated directly by light which passes from the lamp through the unsilvered part of the hypothenuse, while the other half of the slit is illuminated by light from the same lamp, but which is reflected first from a mirror on to the silvered part of the hypothenuse-face and thence reflected on to the slit. The solutions to be compared are placed in suitable vessels in the two beams, and the thickness of one is adjusted until equality of spectral intensity is produced. To obtain an adjustable thickness of solution the reflected beam is made to pass vertically from one mirror to the other, and two glass vessels, one inside the other with the solution between them, are interposed in the vertical beam. By raising or lowering one of the vessels inside the other the thickness of the layer of solution is altered at will. J. B. H.

1646. *Absorption Spectra of Carbon Compounds.* **L. Puccianti.** (Phys. Zeitschr. 1. pp. 49–51, 1899.)—Monochromatic light obtained by means of a spectrometer was allowed to pass through the absorbing medium, and the intensity of the rays was then measured by a torsion-radiometer. The absorption spectra of benzene, toluene, orthoxylene, and methyl iodide were thus examined. Toluene has three absorption maxima in positions similar to those of benzene; it has, moreover, two strong absorption bands in coincidence with those of methyl iodide. The results are in agreement with the hypothesis that the absorption depends on the groups of atoms which exist in the molecule. J. J. S.

1647. *An Optical Illusion.* **C. H. Wind.** (Phys. Zeitschr. 1. pp. 112–113, 1899.)—The author describes a contrivance for exhibiting in a striking manner the optical illusion discovered independently by Mach and himself, which enabled them to refute the alleged production of interference fringes by Röntgen rays. Two slits are placed parallel to each other at a distance of 2 or 3 cm. The image of any source of light is projected on to the first slit so as to cover it completely, and the light penetrates the second slit and falls on a screen beyond, placed at a distance of 3 or 4 m. Now let the width of the first slit be gradually increased from zero, and let the second one be kept at a width of 2 or 3 mm. At first, true diffraction fringes appear, but afterwards a bright fringe begins to detach itself from each edge and to travel towards the middle. This fringe is entirely due to the optical illusion previously described [see Abstract No. 1871 (1899)]. When the two fringes coincide in the centre, there exists for the moment a true maximum of light. Another instance of the illusion is obtained when a needle or wire is substituted for the second slit. The bright lines travel outwards from the full shadow, and at a certain stage the latter appears doubled. The illusion can be destroyed by covering over the central portion with a suitable screen. Strict parallelism of the slits is essential to success. E. E. F.

1648. *Dual Nature of Radium Rays.* **P. Villard.** (Comptes Rendus, 130. pp. 1178–1179, April 30, 1900.)—An experiment is described which brings out clearly the heterogeneous nature of the rays given out by "radium" preparations. Radium rays are transmitted through a slit in a lead plate, and impinge at nearly grazing incidence upon two sensitive plates laid one over the other and wrapped in black paper. The rays are exposed to a strong magnetic field. It is evident that under these circumstances the upper plate receives rays which have traversed the black paper only, while the lower one receives rays which have traversed in addition the glass and film of the upper plate, and an increasing thickness of both as the angle of incidence increases towards the edge. On development the upper plate shows two impressions —one deviated and spread out, the other feebler, but absolutely rectilinear and sharp. On the lower plate only one impression is visible, that due to the non-deflected rays. The impression is as clear as that on the upper plate, and indeed clearer, if anything, owing to the absence of fog. A prolonged exposure brings out a very feeble indication of the deflected rays. A band of lead 0·3 mm. thick, laid across the upper plate, intercepts the deflected rays over its whole width, whereas the rectilinear rays are only weakened. Thus the two classes of rays may be distinguished from each other in the region where they are superposed. The author simply calls the two classes of rays X-rays and kathode rays. E. E. F.

1649. *Transparency of Aluminium to Radium Rays.* **H. Becquerel.** (Comptes Rendus, 130. pp. 1154–1157, April 30, 1900.)—Radio-active barium chloride fills a groove 1 mm. wide in a block of lead, which is placed between the poles of an electromagnet, so that the groove is parallel to the lines of force. A cylindrical copper bar 4 mm. diameter is placed 11·5 mm. above the groove and parallel to it, and at an equal distance above this is a photographic plate in a black envelope. In this way a shadow image is obtained, which may be displaced to the one side or the other by magnetic fields, in one direction or the opposite. When an aluminium plate, 0·1 mm. thick, is interposed above or below the copper bar, and inclined at 45°, the shadows have the same size, but are weakened by diffusion, and are not quite so far apart as

before. The experiments made confirm his previous ones, and the author is opposed to Villard's conclusion that the rays which undergo deviation behave like kathode rays, and emerge normally to the plate traversed. G. E. A.

1650. *Radio-active Barium.* **B. v. Lengyel.** (Ber., 33. pp. 1237–1240, 1900.)—It is probable that all the radio-active "elements" which have been assumed to exist in conjunction with bismuth, lead, barium, and titanium are identical, since in every case pitchblende has been used as the crude material for their preparation. Ordinary barium has been rendered radio-active by heating the nitrate with uranylnitrate; the compounds prepared from this active material possess all the properties of the barium compounds in which the existence of "radium" has been postulated. It is therefore extremely unlikely that "radium" is a hitherto unknown element, for it would appear that the barium merely extracts the active material from the uranium, and that only one active material exists in the two preparations. T. M. L.

REFERENCES.

1651. *Spectra of Oscillatory Discharges.* **B. Hasselberg.** (Journ. de Physique, 9. pp. 153–155, March, 1900.)—Referring to the recent articles by G. A. Hemsalech on the variation of the spectrum of an oscillatory discharge produced by the introduction of self-induction into the circuit (Journ. de Physique, 3rd series, 8. p. 652, 1899; Comptes Rendus, 129. pp. 285–288, 1899; Science Abstracts, 1899, No. 1860), the author calls attention to previous work by Thaler and by Kirchoff many years ago. C. P. B.

1652. *Demonstration of Absorption Spectra.* **E. J. Formánek.** (Zeitschr. Instrumentenk., Beib. 5. pp. 41–43, March 1, 1900.)—Description of an arrangement for bringing a number of tubes containing different dye or salt solutions successively before the slit of a spectroscope. T. H. P.

1653. *Magneto-Optic Effects.* **W. Voigt.** (Phys. Zeitschr. 1. pp. 116–120, 128–131, 138–143, 1899.)—History of the Zeeman effect, with sketch of Lorentz's theory. G. E. A.

1654. *A New Refractometer.* **C. Pulfrich.** (Zeitschr. Instrumentenk. 19. pp. 335–339, 1899.)—A description of a refractometer of variable refracting angle. The method depends partly on an application of total reflection, and is shortly defined as the method of grazing incidence and normal emergence. J. J. S.

1655. *Theory of the Microscope.* **K. Strehl.** (Zeitschr. Instrumentenk. 19. pp. 325–335, 1899.)—This is an elaborate mathematical paper on the formation of images in the microscope, supplementing a former investigation by the author. [See Abstract No. 1137 (1899).] J. J. S.

1656. *Colour Photography.* **J. W. Hinchley.** (Soc. Chem. Ind., Journ. 19. pp. 5–7; Discussion, pp. 7–8, Jan., 1900.)—After a brief survey of the progress of colour photography, the author describes in detail the manufacture of the ruled screens employed in the Joly process, mentioning the difficulties at first encountered, and the means adopted for overcoming them. G. H. B.

1657. *Zeeman Effect.* **H. A. Lorentz.** (Phys. Zeitschr. 1. pp. 39–41, 1899.)—A short discussion of the theories put forward by the author, and by Voigt, Poincaré and others, to explain the Zeeman effect, including the observed phenomena as to triplets and quadruplets. J. J. S.

HEAT.

1658. *Specific Heats of Fluids.* **E. H. Amagat.** (Comptes Rendus, 130. pp. 1443–1447, May 28, 1900.)—The author has plotted 44 isopiestics on a v-t diagram from the results of his experiments on CO_2, over a range of 1,000 atmospheres and between 0° and 260° C. From these curves he has obtained the values of $\partial v/\partial t$ for 25 temperatures, and has plotted the results with temperatures as abscissæ, and from these new curves he has obtained the values of $\partial^2 v/\partial t^2$ for these temperatures, and has plotted them with the corresponding *pressures* for abscissæ. Thence by simple quadrature he obtains the difference between the isopiestic specific heats for the same temperature and different pressures, since

$$J\,(\partial C/\partial p)_t = -t\,(\partial^2 v/\partial t^2)_p.$$

Quantitative results are reserved for future notes, but the curves show that for a temperature above the critical point, C increases with the pressure at first rapidly (especially for low temperatures) and then less rapidly, attaining a maximum value at a pressure, given by $\partial^2 v/\partial t^2 = 0$, which continuously increases with t and afterwards diminishes, at first rapidly and then less and less rapidly, as the pressure continues to increase: also that for a temperature below the critical point, C increases with the pressure till the state of saturation is reached, but then undergoes an abrupt change (the sign of which is not *à priori* assignable) and afterwards decreases indefinitely and less and less rapidly as the pressure continues to increase, so that its maximum value occurs when the vapour is saturated, and therefore at a pressure which increases with t as before. Further, that the maximum value of C is the greater the nearer the corresponding pressure is to the critical point, being infinite at the critical point; lastly, that for the gaseous state the variations of C decrease indefinitely as the temperature increases, becoming extremely small, and also, from and after a certain pressure for each temperature, they decrease indefinitely with increase of the pressure. A mode of calculating the abrupt variation of C accompanying the change of state is also given. R. E. B.

1659. *Limits of the Solid State. Part IV.* **G. Tammann.** (Ann. d. Physik, 2. 1. pp. 1–31, May, 1900.)—Last year (see 1899, Abstract No. 1693) the fusion curve of ice was traced up to pressures of 2,200 kg. per sq. cm. The author has since examined the region from 0° to −80° under pressures of 1 to 3,200 kg., and two special areas, one from −22° to −15° under 3,200 to 4,000 kg., and another from −80° to −180° under 1 kg. per sq. cm. It appears that within these limits water can appear in four distinct states, termed by the author water, ice I, ice II, and ice III respectively. Ice I is ordinary ice. The transformation curves of ice II and ice III into ordinary ice are of special interest, since they are both retrograde, and each of them shares two temperatures of equilibrium under the same pressure. While the fusing curve of ordinary ice passes to lower temperatures under increased pressure, the fusing curves of the other two varieties pass to higher temperatures. To reach one of these fusing curves, an artifice is necessary. The temperature of ordinary ice must be brought below −22°, and the pressure must be brought

up to at least 2,400 kg. per sq. cm. If the temperature is reduced from -30° to -60°, ice III is obtained. At -80° ice II is obtained. If now the volume is reduced until all the ordinary ice is transformed, an increase of temperature under a pressure of 2,500 kg. or more, yields one of the fusing curves, according to the kind of ice generated. The maximum transformation pressure of ice I into ice II is 2,252 kg. at -34°, and the corresponding maximum for ice I into ice III is 2,255 kg. per sq. cm. at -43°.

[In Ann. d. Physik, 2. 2. p. 424, June, 1900, the author states that the pressures in the above paper should have been put as kg. per sq. cm. instead of atmospheres. This correction has here been introduced.]

E. E. F.

1660. *Thermal Conductivity of Gases.* **E. Warburg and E. Gehrcke.** (Ann. d. Physik, 2. 1. pp. 102–114, May, 1900.)—If a gaseous layer is contained in the spherical shell between two concentric metallic spheres, convection is practically eliminated if the interval is small enough. If, therefore, the effect of radiation can be eliminated as well, it is possible to determine the thermal conductivity of the gas by observing the rate of cooling of the hotter inner sphere. This reasoning is, however, disturbed by the observation that when the pressure is reduced below a certain small amount, it begins to influence the apparent conductivity of the gas. This is explained by a discontinuity at the metallic surfaces, due to a discontinuity of temperature. The discontinuity of temperature may be defined by a length γ, such that at that distance from the wall the temperature would become equal to that of the nearest layer of the gas if the gradient were continuous. The virtual thickness of the gaseous layer is therefore increased by 2γ. If we suppose that γ is directly proportional to the mean free path λ, and therefore inversely proportional to the pressure, an explanation is furnished of the fact that the conductivity diminishes with the pressure at an increased rate the smaller the thickness of the gas layer. The authors determined the ratio γ/λ for air and hydrogen at low pressures, using co-axial cylinders of silvered brass instead of the glass tubes used by Smoluchowski. The cooling body was a mass of water contained in the interior cylinder. The ratio was found to be 1·83 in the case of air and 5·70 in the case of hydrogen. With increasing exhaustion, the ratio decreases after the mean free path has reached the value of 0·15 mm. In fact, the discontinuity of temperature tends to disappear when the molecules, owing to exhaustion or widening of the interval, acquire a certain freedom of motion. E. E. F.

1661. *Thermal Unit.* **E. Warburg.** (Phys. Zeitschr. 1. pp. 171–173; Discussion, p. 173, Jan. 6, 1900. Read before the 71st Naturforscherversammlung in Munich.)—After reference, historical and critical, to the establishment of the Regnault 0°–1° unit, the author considers that, in view of our knowledge of the change in the specific heat of water from 0° upwards, it is now necessary to redefine the unit of heat. Retaining the erg as theoretical unit, he gives the preference to a water calorie defined for a specific temperature as a secondary unit, and proposes to define the calorie as the quantity of heat that would raise a gramme of water from 14½° to 15½°. G. E. A.

1662. *Gibbs' Thermodynamic Model.* **W. P. Boynton.** (Phys. Rev. 10. pp. 228–233, April, 1900.)—Having found a difficulty in locating the directions of the axes in Maxwell's diagrammatic representation of Gibbs' model, the author has attempted, but without satisfactory success, to determine them by

consideration of the properties of the critical state as given by van der Waals' characteristic. [But in his ϕ-v diagram he draws his dotted curve of saturation so that in the neighbourhood of the critical point there are two values of v for every one of ϕ. He also draws the isothermal for the critical temperature as thrice intersecting the isentropic through the critical point.] R. E. B.

1663. *Joule and Kelvin Effect.* **D. Berthelot.** (Comptes Rendus, 130. pp. 1379–1381, May 21, 1900.)—In previous papers (see Abstracts, Nos. 541 and 721, 1899) the author has given reasons for thinking that the Joule and Kelvin effect is closely connected with the values of pv/T; that, in fact, the maxima and minima of the isopiestics drawn with $y \equiv pv/T$ for ordinate and T for abscissa give the temperatures of inversion of this phenomenon. Van der Waals' reduced characteristic, with v eliminated and $\psi \equiv \pi v/\tau$ introduced, becomes

$$(3\psi - 8)\,\psi^2\tau^3 = \pi\,(\psi^2\tau^2 - 9\psi\tau + 3\pi),$$

and gives

$$(3\psi - 8)\left\{(\psi\tau + 9)^2 - 108\tau\right\} = 0$$

for the locus of the maxima and minima points on the isopiestics. On this theory, therefore, the intersection of this curve by an isothermal gives the pressure for which the inversion occurs at the temperature corresponding to the isothermal, and its intersections by an isopiestic give the two temperatures of inversion for the corresponding pressure. This locus has a maximum ordinate (given by $\psi = 3 = \tau$) corresponding to $\pi = 9$, showing that at this pressure the two temperatures of inversion coincide, and that at pressures greater than 9 no inversion at all occurs. [On this theory the pressure for inversion at τ is $24\sqrt{(3\tau)} - 12\tau - 27$, and the temperatures for inversion at π are $\frac{1}{12}\left\{6 \pm \sqrt{(9 - \pi)}\right\}^2$.]

Amagat's curves for nitrogen differ considerably from those just discussed, but they indicate similar singularities, giving about 12 in place of 9 for the pressure above which no inversion of the sign of ψ occurs, and about 2½ in place of 3 for the coincident temperatures of inversion under this limiting pressure. [In the paper read 0·985 for 0·975.] R. E. B.

REFERENCES.

1664. *Specific Heat of Blood.* **H. Bordier.** (Comptes Rendus, 130. pp. 799–800, March 19, 1900.)

1665. *Comparison of Platinum and Gas Thermometers.* **J. A. Harker** and **P. Chappuis.** (Roy. Soc., Phil. Trans. 194. pp. 37–134, March 13, 1900.)—Full account of the investigation referred to in Abstract No. 637 (1900).

ELECTRICITY.

THEORY AND ELECTROSTATICS.

1666. *Magnetic Field produced by Motion of an Electrified Body.* **V. Crémieu.** (Comptes Rendus, 130. pp. 1544–1549, June 5, 1900.)—According to Maxwell an electrified body in rapid motion should produce a magnetic field in its neighbourhood. Experiments made by Rowland in 1876, and by Rowland and Hutchinson in 1889, appear to have confirmed this. The author has repeated the test under more favourable conditions. Instead of observing, as Rowland did, the direct action of a revolving charged disc upon a magnetised needle, he has examined the inductive action of a similar disc upon a neighbouring circuit. A description (with figures) is given of the apparatus and method used; and the galvanometer readings calculated in accordance with theory are compared with those actually observed. The former should amount to 22·3 mm. with the lowest rates of revolution and superficial density of charge employed, and to 51·8 mm. with the highest. The actual readings lie between zero and 4 mm., and are stated to be due to unavoidable displacements of zero during the course of an experiment. The author concludes that the motion of an electrified body does not appear to produce any magnetic effect in its neighbourhood. D. E. J.

1667. *Imaginary Quantities and the Representation of Periodic Complex Functions.* **C. F. Guilbert.** (Écl. Électr. 22. pp. 405–414, March 17, 1900.) —The author's investigations are founded on a memoir by Steinmetz on the representation of vectors by imaginary quantities. He refers also to two memoirs by Janet [see Abstracts, Nos. 291 and 292 (1898)]. The object of the present paper is to extend Steinmetz's theory, which the writer says assumes that the periodic functions considered are sinusoidal, or can be replaced by equivalent sinusoidal functions. And this hypothesis fails in cases such as circuits containing capacities, or in which the resistances or self-inductions vary periodically. Steinmetz in a recent memoir has extended his theory, making use of the principle that when a non-sinusoidal tension acts on a circuit containing resistances, self-inductions, and capacities, each separate harmonic tension produces its full effect as if it had a circuit similar to the given one to itself. The author proceeds to explain that when the different harmonic tensions have different frequencies the terms under the symbol $\sqrt{-1}$ do not admit of being added algebraically, and this he shows by attaching an index to the symbol in the form $\sqrt{-1_n}$. In this memoir the equation—

$$I = \Sigma(i'_n + \sqrt{-1}_n i''_n) = \Sigma \frac{e'_n + \sqrt{-1}_n e''_n}{r + \sqrt{-1}\left(ns + s' + \frac{s''}{n}\right)}$$

signifies that for each value of n we have the equation—

$$i'_n + \sqrt{-1}_n i''_n = \frac{e'_n + \sqrt{-1}_n e''_n}{r + \sqrt{-1}_n\left(ns + s' + \frac{s''}{n}\right)}.$$

Steinmetz has given several examples of his method, two of which are worked out in detail by Guilbert. S. H. B.

1668. *Contact Force.* **O. J. Lodge.** (Phil. Mag. 49. pp. 351–383, April, and 454–475, May, 1900. Presidential Address to the Physical Society of London.)—The author endeavours in the first place to state the various views that are at present held as to the character of the contact electromotive force. The relations between the thermoelectric quantities, Π the coefficient of the Peltier effect, σ of the Thomson effect, and the electromotive force E, are clearly stated, it being shown that the thermodynamic equation

$$\Pi = \mathrm{T}\,\frac{d\mathrm{E}}{d\mathrm{T}}$$

is in general only true for the whole of a closed circuit, and that Π is therefore not necessarily a measure of the electromotive force existing at a particular junction. Further, the view that the Volta contact force is the quantity whose differences and derivatives constitute the E.M.F.'s observed in thermoelectricity is regarded as an arbitrary assumption by the author, although one that may be true, since there is at present no disproof of it. In Chapter II. the facts of contact electricity are described, the main phenomenon being stated in the words "The Volta effect consists in an opposite charge acquired by dry zinc and copper while in metallic contact, a charge which results from an E.M.F. of value depending on the condition of their outer surfaces and controlled solely by this E.M.F. and the electrostatic capacity." Attempts have been made to relate this quantity to the heat of formation of brass from copper and zinc, but so far the evidence is too indefinite to draw any conclusions, but since no formation of alloy takes place when a current is passed across a junction, there seems no reason *à priori* to expect a relation.

In the fourth chapter the possible mechanism of the contact force is discussed. The author shows that to maintain his view that it is due to the action of oxygen on the two metals it is not necessary to assume any actual chemical combination, but only an extremely minute approach of the oxygen atoms towards the zinc, and a recession from the copper.

The customary electrochemical theory of the voltaic cell is then stated, and is followed by a discussion of the bearing of the electron theory on the production of electromotive force. It is suggested that conduction in the metals is due to passage of isolated charged corpuscles from one atom to the next; but this does not cause any chemical change, because, even if the conduction takes place across a junction between two metals, each atom on gaining one negative corpuscle loses a similar one, so that the amount of each metal remains the same. In electrolytes, however, the charged corpuscles drag their atoms (or groups of atoms) with them, so that chemical changes occur. The author then develops an ingenious theory (based, necessarily, however, on several unverifiable assumptions) as to the electromotive forces due to the movement of the corpuscles, following the analogy of Nernst's theory of diffusion cells, attributing to the charged corpuscles of opposite sign, definite mobilities u and v, *i.e.*, velocities under the influence of unit electric intensity. He obtains in this way a convenient expression for the various thermoelectrical quantities, arriving, *inter alia*, at the conclusions that the Hall effect ought to have the same sign as the coefficient of the Thomson effect, and that the thermoelectric power should be largest for metals of largest resistivity, as is actually the case. Helmholtz's view of a specific attraction of matter for electricity the author considers may be regarded as a primitive form of the electron theory. R. A. L.

DISCHARGE AND OSCILLATIONS.

1669. *Potential Gradient in Vacuum Tubes.* **H. A. Wilson.** (Phil. Mag. 49. pp. 505-516, June, 1900.)—The potential gradient and the conductivity of the gas in a vacuum tube is studied by a new probe which can be shifted into any part of the discharge at will. The discharge passes through a Torricellian vacuum, and an open glass tube containing the two electrodes floats on the mercury, whose surface can be raised or lowered by means of an indiarubber tube with thistle funnel. The upper electrode is connected with the outside by a flexible coil of thin brass wire.

Thus the vacuum tube proper floats up and down in the vacuum, and through the slit in its side the probes fixed into the side of the barometer tube are capable of entering. This arrangement secures a free displacement of the probes with respect to the discharge.

The author reproduces a number of diagrams showing the distribution of the potential gradient. There is a sudden drop of potential near the anode, often amounting to as much as 85 volts. The author confirms this by substituting mercury jets for the platinum probes, and attributes it to the great rate at which positive ions are shot off from the anode. He also studied the conductivity of the gas by means of the same probes, and obtained results generally confirming those of Stark [see Abstract No. 1459 (1900)]. E. E. F.

1670. *Luminous Effects on Wires Conveying Electric Discharges.* **J. Borgman.** (Comptes Rendus, 130. pp. 1179-1182, April 30, 1900.)—A metallic wire which is not covered by an insulating layer becomes covered with a luminous aureole when it is inserted in the circuit of an induction coil containing a spark-gap or a vacuum tube. The author has further investigated this phenomenon by means of wires sealed into cylindrical tubes, and traversing their axis. The tubes were several feet long and 3 cm. to 6 cm. wide. Some of the tubes were traversed by capillary glass tubes containing liquid conductors. As exhaustion proceeds, the luminous phenomena show a peculiar development. The aureole decreases in intensity, and is gradually replaced by a series of equidistant stars, around which luminous discs are formed with their planes at right angles to the wire. The number of stars and discs increases, until the latter touch each other and fill the whole tube with a luminosity having a slightly stratified aspect. These effects are the same whether the tube is attached to the positive or the negative terminal of the secondary. When a spark-gap is inserted in parallel with it, and the wire is attached to the negative terminal, there is only a continuous luminous envelope, which broadens out as exhaustion proceeds and finally detaches itself from the wire. The stars reappear on attaching the wire to the positive terminal, and at a certain pressure the discs reappear also, their diameter increasing with the length of the spark-gap. As exhaustion proceeds, the number of discs decreases, some of them remaining, while others disappear. Finally, they are transformed into nebulæ with a starry nucleus. The approach of a magnet has the effect of inclining the plane of the rings. E. E. F.

1671. *Powerful High-frequency Currents.* **d'Arsonval.** (Comptes Rendus, 130. pp. 1049-1054, April 17, 1900.)—A description of arrangements employed by the author in the decoration of the façade of the Palace of Electricity at the Paris Exhibition of 1900. Highly luminous and very brilliant sparks were required, some to be short and others much longer. To produce these

the discharge of powerful condensers has been employed, these latter being charged by transformers at high potential actuated by alternators. A description is given of the transformer, condenser, exploder, and transforming coil. The transformer is of the Labour type with closed magnetic circuit. It can absorb up to 30 kilowatts. The condenser, after trial of many substances, was finally made with micanite as insulating material, with sheets of tin-plate. The micanite is formed by gluing together when hot, with gum lac and under high pressure, very thin sheets of mica. The whole is plunged in a glass vessel containing ordinary petroleum, which acts as an excellent insulator. The condenser thus formed behaves admirably: there is no heating, as there is no electrolysible substance. The discharge spark of the condenser takes place between two balls. A continuous arc is formed which can be blown aside by a magnetic field, but preferably by a jet of air. The rotatory exploder has been devised to get a convenient means of blowing the spark. Two metallic rods with spheres at their ends are made to rotate rapidly, describing in air a circumference whose diameter varies in different cases from 30 cm. to 200 cm. and more. Thus a strong wind is produced between the balls simply by their displacement in air with an insignificant expenditure of energy. When in these circumstances the spark passes a very interesting luminous phenomenon is produced; the effects resembling those obtained with a revolving mirror, but being much more luminous. The author's transforming coil, by which the long sparks required are obtained, is next described. The arrangement is similar to that used by Elihu Thomson. The induced and inducing circuits are concentric and immersed in a vessel of oil. Long and brilliant sparks are obtained, and the length can be increased several times by making them pass to plates of marble covered with thin sheets of metal, preferably zinc. J. J. S.

1672. *Discontinuities in the Laws of Electric Discharge in Gases.* **W. Kaufmann.** (Ann. d. Physik, 2. 1. pp. 158–178, May, 1900.)—A continuous change of any of the elements governing a vacuum discharge, such as the E.M.F., the external resistance, the temperature, or the pressure, often produces a sudden and discontinuous change in the current strength and the potential gradient, usually characterised by a change in the appearance of the discharge. The author investigates the relations which must exist between the variables in order that a given current should be stable.

The relation between the stationary current J and the difference of potential E at the ends of the gaseous conductor may be expressed by an empirical curve of the form—

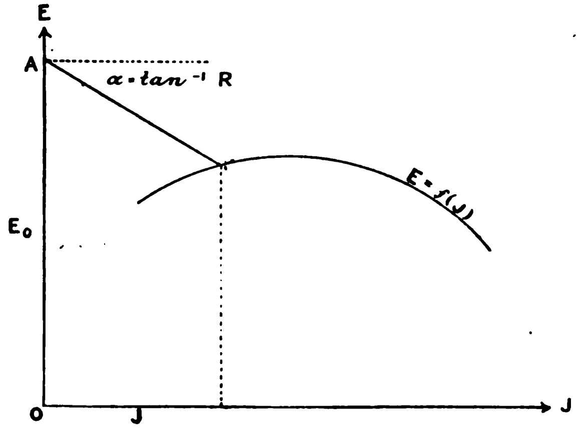
$$E = f(J)$$

which may be termed the "characteristic curve" of the gaseous conductor. Any one of the indefinite number of pairs of values of E_0 and R (the total resistance) belonging to a given current J may be calculated from the equation—

$$E_0 - JW = E = f(J)$$

If $f(J)$ is not given as an equation, but as a curve, it will as a rule be most convenient to solve the equation graphically. For this purpose, J is entered as an abscissa and E as an ordinate in a rectangular system (see diagram). Through the proper point of the curve $E = f(J)$ a straight line is drawn which may intersect the axis of ordinates in A. Then if $E_0 = OA$ and

$R = \tan \alpha$, the above equation is fulfilled, and E_0 and R are one of the pairs of values sought. The author shows that they are stable if the line $E_0 - JW$ is tangent to the characteristic curve, and illustrates this rule by



reference to the transition from the spark discharge to the glow discharge and the arc discharge. E. E. F.

1673. *Current at Break.* **K. R. Johnson.** (Ann. d. Physik, 2. 1. pp. 179–185, May, 1900).—The author objects to Arons' theoretical treatment of the current at break, given in 1897, that owing to the transition resistance at the surface of the metal there is no continuous increase of resistance to infinity at break, as assumed by Arons. He substitutes another treatment, which gives the conditions under which the spark at break can be avoided. He comes to the conclusion that the current at break is essentially a transformation of the electric energy of the circuit into Hertzian waves. The wave train is suddenly terminated when the spark passes. E. E. F.

1674. *Transient Deflection of Kathode Rays.* **P. Villard.** (Comptes Rendus, 130. pp. 1177–1178, April 30, 1900.)—In 1896, G. Jaumann described what he believed to be a peculiar property of kathode rays. He immersed a very highly exhausted vacuum tube in ordinary vegetable oil. The tube was provided with a single electrode, which served as a kathode, while the anode was outside the tube and in the oil. When the tube was working the approach of a charged glass rod apparently produced a repulsion of the beam of kathode rays and the fluorescent spot produced by it. This repulsion rapidly subsided while the glass rod was held in the same position. When the rod was removed, or when the charge was of the opposite sign, the repulsion became an attraction. The author has repeated the experiment and verified the effects as stated, but he does not follow Jaumann in ascribing them to a peculiar property of the kathode rays, such as the "self-stretching" property which the latter connected with his hypothesis of "longitudinal light." The author points out that commercial oils are very poor insulators, whereas true dielectrics have been shown by Bouty to intercept an electrostatic field as effectively as a layer of mercury. Consequently the electrostatic field produced in the interior of the tube by the glass rod outside depends upon the conductivity of the oil, and if the oil takes some time to adjust itself to an

external field, there will be an electrostatic process within the oil which may well last a second. Such a process would explain the temporary deflection of the kathode beam described. In confirmation of this explanation the author replaces the kathode beam by a conductor joined through a screened wire with an electroscope outside. A temporary deflection of the electroscope is then observed, corresponding to the deflection of the kathode beam. E. E. F.

1675. *Photochemical Effects by Wires Radiating from Hertzian Oscillators.* **T. Tommasina.** (Comptes Rendus, 130. pp. 1462–1465, May 28, 1900.)—Rhythmical crepitations may be heard along the "antenna" or radiating wire which forms the prolongation of one of the branches of a Hertzian primary. In the dark, mobile luminous *aigrettes* may be seen around the radiating wire. In appearance they are like those exhibited in Tesla's experiments; they appear to vibrate synchronously, not with the sparks of the oscillator, but with the movements of the interrupter of the induction coil. They cannot be photographed by means of an objective, but figures are given showing the effect produced upon a photographic plate when its sensitive surface is placed in contact with the radiating wire. D. E. J.

1676. *Transparency of Liquids to Electrostatic Oscillations.* **A. de Heen.** (Comptes Rendus, 130. pp. 1460–1461, May 28, 1900.)—The oscillations are produced by connecting *one* of the poles of an induction coil with a metallic conductor. The liquid to be examined is placed in the annular space between two concentric test-tubes. Water, alcohol, aldehyde, and carbon bisulphide are found to be opaque; ether, petroleum, benzene, xylene, butyric acid, and valerianic acid are transparent. D. E. J.

1677. *Energy of Streams of Electric Waves.* **C. Heinke.** (Phys. Zeitschr. 1. pp. 197–200, Jan. 27, 1900. Paper read before the 71st Naturforscherversammlung in Munich.)—The author discusses the various methods of measuring the energy of electric oscillations, with reference to investigations of his own (Elektrotechn. Zeitschr. 20. pp. 510–513 and 527–531, 1899), and finds that the instruments usually employed, viz., galvanometers, Weston and d'Arsonval instruments, &c., give unsatisfactory results. He shows that the instantaneous force may have the opposite sign to that usually attributed to it. His own method is described by the aid of diagrams. In conclusion he maintains that the only instrument which gives the true energy of an electric wave system is the wattmeter; and if that be not obtainable the only trustworthy method is the complete conversion of the energy into heat and its calorimetric measurement. S. H. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1678. *Hysteresis and Viscosity of Dielectrics.* **F. Beaulard.** (Comptes Rendus, 130. pp. 1182–1185, April 30, 1900.)—Arno has shown that a dielectric placed in an alternating electrostatic field gets heated, and that the heating is proportional to some power of the E.M.F. Similarly, Janet has proved that with increasing potentials the charge of a condenser is feebler than it is when the potentials are decreasing. This lag is due either to viscosity or to hysteresis. Arno supports the latter alternative. In that case the dissipation of energy should be independent of the rate at which a cycle is completed. The author's experiments, however, point to the opposite conclusion. He

charged a condenser to the same potential during various time intervals ranging from 4 seconds to 600 seconds, and compared the charges by sending them through a ballistic galvanometer. He found that the loss of energy in the condenser decreased as the time increased, and that if the process of charging the condenser was extended over an interval of fifteen minutes the loss was nil. He therefore concludes that the effect is due to viscosity rather than hysteresis. E. E. F.

1679. *Conductivity and Permeability of Iron Alloys.* **W. F. Barrett, W. Brown,** and **R. A. Hadfield.** (Roy. Dublin Soc., Proc. 7. pp. 67–126, Jan., 1900.)—The authors determined the electric conductivities and magnetic permeabilities of over a hundred alloys of iron manufactured at the Hecla Steel Works, Sheffield. The specimens are divided into three classes. The first class consists of alloys containing one constituent besides iron, and comprises carbon, manganese, nickel, tungsten, aluminium, silicon, chromium, and copper "steels." The second class contains two admixtures, the main admixture consisting of nickel, manganese, chromium, or aluminium. The third class contains three or more admixtures. As regards conductivity, the authors conclude that (1) in all cases a larger, and in some of the alloys a very much larger, increase in electric resistance is produced by the first additions of the added element than for similar amounts added after the alloy is rich in that particular element; (2) the increase in the electric resistance of iron produced by alloying it with an equal percentage of different elements varies through a wide range, according to the nature of the added element, but this increase of resistivity does not appear to be connected with the specific resistance of the added metal; (3) taking the specific electric resistance of mild steel, or of iron containing approximately the same amount of impurities as are present in the alloys tested, to be about 15 microhms per c.c. at the temperature of the air, then the addition of corresponding amounts (say 3 per cent.) of the following metals raises the resistance in the case of annealed alloys of iron and

3 per cent. of	Tungsten	to about	17,	or an increase of		2	microhms.
„	Nickel	„	21	„	„	6	„
„	Chromium	„	24	„	„	9	„
„	Manganese	„	30	„	„	15	„
„	Silicon	„	45	„	„	30	„
„	Aluminium	„	48	„	„	33	„

Among a large number of valuable results may be mentioned the discovery of a nickel-manganese steel having a specific resistance of 97·52 microhms per c.c. at 15°, probably the highest resistivity of any metallic conductor yet obtained as wire in a commercial form. It is sixty times greater than the resistivity of pure copper, nearly ten times as great as that of the best iron, and 4½ times greater than that of German silver. The alloy contains 25 per cent. of nickel, 5·04 of manganese, and 0·6 of carbon.

In the second part of the paper, dealing with the magnetic properties of the various specimens, the most remarkable result is the effect produced upon iron by the addition of silicon. The addition of 2 to 5½ per cent. of silicon to steel increases the magnetic softness to such an extent that the coercive force and retentivity are reduced to nearly one-half of the standard iron rod, which contains only 0·03 per cent. of carbon. The permeability is also higher than that of iron for magnetising forces below saturation. E. E. F.

1680. *Thermo-electricity of Oxides and Sulphides.* **A. Abt.** (Ann. d. Physik, 2. 2. pp. 266–279, June, 1900. Paper read before the Hungarian Academy of Science, Dec. 18, 1899.)—The author combines various metals with a number of oxides and sulphides, and discovers some thermoelectric couples of very high E.M.F. The resulting figures are given on an arbitrary scale, in which the E.M.F. of a bismuth-antimony couple with its junctions at 98·1° and 1·4° respectively appears as 200. Under the same circumstances, the following E.M.F.'s are obtained (in arbitrary units) :—

Pyrolusite-Bismuth	210·6	Chalcopyrite-Bismuth ...	542·2
Pyrolusite-Antimony	396·9	Chalcopyrite-Antimony ...	669·3
Pyrrhotite-Antimony	21·7	Pyrite-Pyrolusite	933·2
Pyrrhotite-Bismuth	178·0		

The highest value obtained is that of the couple Pyrite-Chalcopyrite, whose E.M.F. is 7·62 times that of the bismuth-antimony couple. E. E. F.

1681. *Thermoelectric Properties of Alloys.* **É. Steinmann.** (Comptes Rendus, 130. pp. 1300–1303, May 14, 1900.)—The results are given for the E.M.F. between 0° and 100° of couples formed of chemically pure lead and the following alloys: Ten nickel-steels, four platinum-iridiums, three aluminium bronzes, five telegraph bronzes, five brasses, and four German silvers. The E.M.F. was measured by a modified Poggendorff compensation method, the curve being determined for five temperatures of the hot junction. G. E. A.

1682. *Earth Resistance of Lightning Conductors.* **R. Nowotny.** (Zeitschr. Elektrotechn. Wien, 18. pp. 279–281, June 3, 1900.)—In the case of lightning conductors whose upper portions are in connection with any conducting masses attached to, or on the roof of, the building, it becomes necessary, in testing the resistance of the earth connection, to provide some method of entirely disconnecting the lower earthed portion of the conductor from its upper portion, which is indirectly earthed on account of being connected to metal work about the building. For the purpose of enabling this test to be carried out, it has been usual to specify—notably in the case of conductors attached to derricks supporting telephone wires—a coupling by means of which the upper portion of the conductor could be disconnected when carrying out the earth test. The author describes a method devised by E. Ruhstrat which enables the coupling to be dispensed with. The method is a modification of a Wheatstone's bridge, alternating currents being employed. Three measurements are necessary; the first gives the ratio of the two earth resistances corresponding to the upper and lower portions of the conductor respectively, while the other two, in which an auxiliary independent earth connection is used, supply two further equations for determining the absolute values of the quantities required. In the first test a portion of the conductor about 1 metre long is made to form a diagonal of the Wheatstone's bridge, and has a telephone receiver connected across it. A. H.

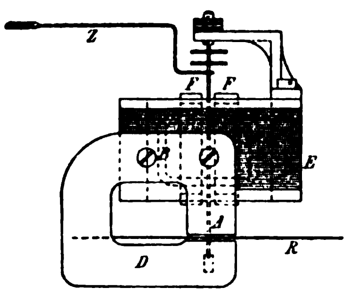
1683. *Testing in Cable Factories.* **H. W. Fisher.** (Elect. World and Engineer, 35. pp. 701–703, May 12, 1900.)—Diagrams of a special testing set are given whereby a switch having five positions enables the following five readings to be immediately taken: Condenser constant, cable capacity, cable resistance, resistance constant, and Wheatstone's bridge. The galvanometer is hung on springs loaded with 500 lbs. supported on a pneumatic cushion.

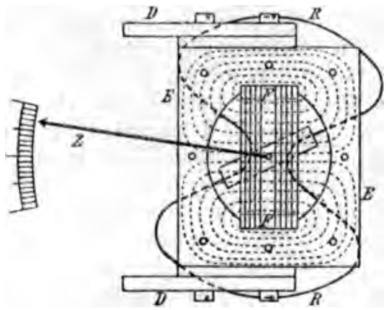
A megohm is permanently in series with the cells when testing insulation, and 40,000 ohms when testing capacity. A small thermal cell provides current for checking the galvanometer deflection. M. O'G.

1684. *Variations of Clark Cells.* **A. P. Trotter.** (Phys. Soc., Proc. 16. pp. 496–504; Discussion, pp. 505–508, 1899.)—A number of Clark cells by different makers are compared among themselves periodically by means of a Crompton potentiometer, with a view to setting up a commercial standard for Cape Colony.

Curves are given, showing the variations of six Muirhead cells and two Wolff cells from a seventh Muirhead cell taken as standard. The internal resistance of the Muirhead cells was measured by finding the galvanometer deflection for a given displacement of the potentiometer slider. G. E. A.

1685. *Alternate Current Instruments.* **G. Benischke.** (Elektrotechn. Zeitschr. 21. pp. 399–401; Discussion, pp. 401–403, May 17, 1900.)—The instruments described and illustrated in this paper are designed to indicate accurately with both direct and alternating currents, and are made by the Allgemeine Elektricitäts-Gesellschaft. They are all dynamometric, and mag-





netically damped. The essential parts of the instruments are shown in the figure for the voltmeter, in which E is a piece made of laminated iron having an aperture in the middle limited by circular arcs. The stationary coil F is mounted in this aperture, and in the stationary coil is arranged the movable coil on its arbor A. On this arbor there is also the pointer Z and the double aluminium blade R, the outer edges of which move between the poles of the two damping-magnets D, D. The iron E is so arranged that it takes up practically all the lines of force generated by the coils, so that the damping-magnets are not influenced thereby. The fixed and moving coils are of copper wire (130 ohms together), and are arranged in series with each other and with a resistance (2,000 ohms) for an instrument reading to 125 and 250 volts. In the wattmeter the fixed series coil is made with two windings, the four ends of which are brought to the four blocks of a plug-switch, so that they can be arranged in series or in parallel as desired. The readings are rendered independent of the difference of phase between the pressure and current by making the correction factor in Stefan's formula unity. This formula is as follows: $L = C \frac{1 + \tan^2\psi}{1 + \tan\phi \tan\psi}$, where L = energy; C = energy when the current is exactly in phase with the pressure; ϕ = the angle expressing the difference of phase between the current and pressure in the main circuit; and ψ = the angle expressing difference of phase in the shunt

of the wattmeter. The desired result is obtained when $\tan\psi = 0$. Now $\tan\psi$ is the ratio of the inductive resistance to the ohmic resistance in the shunt coil of the wattmeter, and this ratio $= 0$ when the inductive resistance is negligible relatively to the ohmic. For the same reason the instrument is practically independent of variations of periodicity. The magnetisation of the iron is so low that there is no appreciable hysteresis effect. In the ammeter the fixed coil is traversed by the current to be measured, and the movable coil is arranged as a shunt to a resistance in series with the fixed coil.

In the discussion **A. Franke** questioned the expediency and also the possibility of making a wattmeter which would indicate correctly with differences of phase amounting to 80°. He also mentioned that he had not been able to obtain aluminium sufficiently free from iron to be applicable for use in magnetic fields. The author in reply stated that in calibrating with direct and alternating currents there was only a difference of 0·2 per cent. in the ammeter and a difference of less than 0·5 per cent. in the wattmeter.

C. K. F.

1686. *Magnetic Balance.* **H. du Bois.** (Zeitschr. Instrumentenk. 20. pp. 113–121, April, and pp. 129–140, May, 1900.)—The author describes in full detail a new form of his magnetic balance, for which he claims an accuracy five times that of the original type. (For description of old form, see Ewing's "Magnetic Induction in Iron," 3rd ed., and Zeitschr. Instrumentenk. 12. p. 404, 1892.) Passing over the many differences in constructive detail, which cannot be described in an Abstract, the most important improvement lies in a compensation coil wound outside the main exciting coil, which neutralises the stray field between the test-rod and the outer windings; the result is that the magneto-motive force of the coil is a function of the magnetic flux in the test-rod only, and as this flux may be assumed without appreciable error to be equal throughout the yoke and other parts constituting the magnetic circuit, the equation of the instrument may be written

$$f(\mathbf{B}) = \mathbf{H} - F(\mathbf{B})$$

where $f(\mathbf{B})$ is the magnetic force in the test-rod and $F(\mathbf{B})$ that in the rest of the circuit. This latter function then depends only on the instrument, and is independent of the material of the test-rod. The curve $\mathbf{H} = F(\mathbf{B})$ is given with the instrument, and, if traced together with any **BH** curve measured by the balance, represents the new ordinate from which the abscissæ **H** are to be measured to give the curve of the test-rod.

The test-rod, of either round or square section, must be given a sectional area of 0·5 cm.^{2}; its length between the clamps is 25·2 or 8π cm. It may be fixed in two ways; either a rod 33 cm. in length is held between clamps as in the old balance, or, preferably, a rod 25·4 cm. in length is given hemispherical ends, which fit into hemispherical cavities in two blocks which take the place of the clamps. Besides self-centring the test-rod, this method has the advantage that the junction forms a nearly equipotential surface of the diverging lines of force, and therefore diverts them less than any other from their direction through a perfect junction, with the result that the correction for the spreading out of the lines of force remains constant, whatever be the relative permeabilities of the test-rod and blocks.

For use with short test-rods, 2π or 6·3 cm. in length, conical filling-pieces are provided with a special exciting coil. The exciting coil, used with test-rods of normal length, is wound with 14 layers of wire of 200 turns each, the two outer layers being wound in the contrary direction and serving as the

compensation winding already mentioned; the effective exciting turns are therefore 2,000. The maximum permissible current is 5 amperes.

The upper part of the yoke has two quadratic scales for use with a light and heavy sliding weight, giving two ranges of induction up to and above 5,000 c.g.s. units. The readings, multiplied by 100, give the induction directly in c.g.s. units. G. H. B.

ALTERNATING CURRENTS AND MAGNETISM.

1687. *Variation of Condenser and Choking Coil Currents with the Shape of the Applied E.M.F. Wave.* **A. Russell.** (Inst. Elect. Engin., Journ. 29. pp. 154–168, Jan., 1900.)—This is a mathematical investigation of the effect of different wave forms of applied E.M.F. on condensers and choking coils.

Curves of various families are considered, and the author draws the following conclusions: (1) A knowledge of the effective currents produced in a condenser and a choking coil by a given alternating E.M.F. gives practically very little information about the shape of the wave. (2) The "form factor" is not a suitable name for the ratio $\frac{V}{v_m}$, where V is the effective voltage and v_m its mean value. It would be better to call it the "area-factor" or the "hysteresis factor." (3) The sine curve wave applied to a condenser produces a smaller effective current than any of the other curves considered. If this current is not the smallest produced by any wave it must be something very nearly equal to the absolute minimum. (4) The sine curve wave applied to a choking coil produces a larger magnetising current than any of the other waves considered. (5) In a family of waves of equal height the symmetrical wave produces the maximum choking coil current and the minimum condenser current. W. G. R.

1688. *Magnetic Tests of Sheet Iron.* **J. Epstein.** (Elektrotechn. Zeitschr. 21. pp. 303–307, April 19, 1900.)—To find the hysteresis and eddy losses, strips are cut from the sheet and are made up into four equal bundles, with paper insulation. Each bundle has a magnetising coil slipped on, and the four are fixed firmly together in the shape of a square. An alternating voltage is applied to the choking coil thus formed, and the combined losses are found in the ordinary way by a wattmeter for any desired values of the magnetic induction and the frequency. By using different frequencies the losses can be separated. The losses being given in the form $\eta n B^{1.6}$ and $f n^2 B^2$, the value of η, in some results quoted, ranges from 0·00136 to 0·00191; and f for a certain sample varies from 4×10^{-7}, for sheets 0·4 mm. thick, up to 16×10^{-7} for sheets 0·92 mm. thick. The method is advocated for general commercial use. **F. Niethammer** (Elektrotechn. Zeitschr. 21. pp. 361–362, May 3, 1900) comments on the above paper. W. H. E.

1689. *Relation between Magnetic Disturbance and Sun-Spot Frequency.* **W. Ellis.** (Roy. Astro. Soc., Monthly Notices, 60. pp. 142–157, 1899.)—In this paper the author continues the investigation referred to in Abstract No. 898 (1898). By comparing the curves furnished by the Greenwich magnetographs and the values of the sun-spot frequency, as tabulated by R. Wolf, he concludes that unusual magnetic disturbance is frequent about epochs of sun-spot maximum, and nearly or quite absent about epochs of sun-spot minimum, the general rise and fall in the number of days of great and active disturbance concurrent with variation in sun-spot frequency being

fairly clearly shown by means of a curve. In the approach towards sun-spot minimum there usually comes a time at which great disturbance ceases, while instances of moderate disturbances continue to occur; these ultimately also cease at sun-spot minimum. After passing this minimum the disturbances are quickly renewed, the renewal being much more rapid than was the dying down.

The author also considers the variation in the frequency of magnetic disturbance with the time of year, and concludes that the larger disturbances are more frequent in spring and autumn than in summer and winter. The magnitudes of the spring and autumn maxima appear to be about the same, while the winter minimum is a little better marked than is the summer one.

W. W.

REFERENCES.

1690. *Measuring Instruments.* **H. Armagnat.** (Écl. Électr. 23. pp. 130–140, April 28, 1900.)—An article dealing with various patent specifications, and illustrated by the patent drawings. The instruments include the Addenbrooke electrometer, Blackburn and Spence's galvanometer, Crompton voltmeter, Heap voltmeter, Davis and Conrad's galvanometer, and others.

1691. *Ammeter with Long Scale.* **B. Davies.** (Phys. Soc., Proc. 16. pp. 425–434; Discussion, pp. 434–435, 1899.)

1692. *Magnetic Analogue of the Coherer.* **G. Vassura.** (Rivista Sci.-Industriale, 32. pp. 17–20, Jan. 30, 1900.)—An attempt to trace out an analogy between the action of a coherer and the behaviour of soft iron in the magnetic field. An observation made by Ewing on the behaviour of a *closed circuit* soft iron ring is quoted as if referring to a soft iron *bar*. R. N. L.

1693. *Effect of Heat on Vacuum Discharges.* **G. C. Schmidt.** (Ann. d. Physik, 1. 4. pp. 625–647, April, 1900.)—A paper similar to that referred to in Abstract No. 1071 (1900). E. E. F.

1694. *Ionisation of Gases.* **Langevin.** (Soc. Franç. Phys., Bull. 148. pp. 11–12, May 4, 1900.)—This is a summary of known facts and current theories.

E. E. F.

1695. *Compensation of Errors in Wattmeters.* **L. Kallir.** (Zeitschr. Elektrotechn. Wien, 18. pp. 233–236, May 6, 1900.)—The ordinary wattmeter can be connected in a circuit with the shunt coil attached either between the series coil and the apparatus taking power, or to the other end of the series coil. In the first case, the current through the series coil is too great by that flowing through the shunt, and in the second case, the volts on the shunt are too great by those on the series coil. The author proposes to compensate the error by introducing a second fixed coil.

G. H. B.

1696. *Measuring E.M.F. of Polarisation.* **E. Müller.** (Zeitschr. Elektrochem. 6. pp. 543–547, May 3, 1900.)—The method here used to study the relationship between a gradually increasing E.M.F. applied to an electrolytic cell and the currents produced is specially suited to chemical laboratories and other places where the delicate galvanometer necessary to measure the small currents is not readily obtainable. The only instruments used are two special rheostats and a capillary electrometer. A diagram of connections and other particulars together with the results of some experiments, are given in the paper. J. B. H.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1697. *Modern Explosives.* **W. Macnab** and **E. Ristori.** (Roy. Soc., Proc. 66. pp. 221–232, April 14, 1900.)—The authors are carrying out a series of experiments to determine the actual maximum temperature reached during the explosion of various explosive materials in a closed vessel. For measuring the temperature they use the pyrometric method developed by Roberts-Austen, modifications being introduced to overcome the difficulties of the very high temperature, the extreme shortness of duration of the maximum temperature, and the necessity of carrying out the explosion in a closed space. The calorimetric bomb employed is similar to that already described by the authors, with the addition that in the lid are inserted two insulated conical pins, one of pure platinum and the other of platinum alloyed with 10 per cent. of rhodium. The pins are connected on the outside of the lid with the terminals of the galvanometer, and on the inside with the platinum and platinum-rhodium wires constituting the thermoelectric couple; the portions of the wires in contact are fused together and the junction drawn through a die so as to make it of the same diameter as the rest of the wire. The photographic method of recording the temperature is made use of, the couple being placed in that position of the bomb which is found experimentally to give the greatest and most uniform deflection of the galvanometer. The results of a series of experiments with 10 couples of varying cross-section are given, and show that for cross-sections greater than about 0·00037 square inches in area, the deflection of the galvanometer is inversely proportional to that area; with thinner couples a greater deflection is obtained than would correspond to a straight line law. The deflection for an infinitely thin couple, which would take up instantly the high temperature obtained in the bomb, can hence be deduced and would correspond to the real maximum temperature. The general uniformity of the results obtained by the authors is shown by the following table, which gives the deflections produced with different couples, the charge consisting of 4 grammes of Ardeer Ballistite, containing 70 per cent. gun-cotton and 30 per cent. nitro-glycerine.

Area of section of couple in square inches.	Deflection on Scale in mm.	
	Mean of several readings.	Maximum.
0·00152	83	85
0·00125	97	102
0·00099	112·5	115·5
0·00061	132·5	138·5
0·00053	148	149
0·00037	154	158·5
0·00025	165·5	170
0·00017	189	192

It is found that, within reasonable limits, the size of grain of the explosive exercises no influence on the deflection obtained. Experiments with gun-cotton, cordite, and ballistite show that the lowest temperature is that yielded

by gun-cotton, and that with ballistite the temperature reached is higher as the proportion of nitro-glycerine increases; cordite, although it contains 58 per cent. of nitro-glycerine, yet, on account of the vaseline present, gives a temperature lower than ballistite containing only 30 per cent. of nitro-glycerine, but no vaseline. The results obtained up to the present are purely comparative, and experiments are now in hand for the purpose of determining the value of the galvanometer deflections in degrees of temperature.

T. H. P.

1698. *Nature of Colloidal Solutions of Metals.* **R. Zsigmondy.** (Zeitschr. Phys. Chem. 33. pp. 63–73, April 3, 1900.)—This is a criticism of a paper on the above subject published by Stoeckl and Vanino. The conclusion arrived at by these investigators, *i.e.*, that the so-called colloidal solutions of metals are merely suspensions, is vigorously contested. It is maintained that the optical test is of no value, since only those solutions will be optically "empty" that have the power of precipitating all insoluble impurities. Moreover, the light may be reflected from still undissolved solid particles of a substance, the greater part of which is really dissolved. The author regards colloidal solutions as real solutions, *i.e.*, as homogeneous mixtures, and sums up the characteristics of such solutions. They exhibit in general some osmotic pressure and power of diffusion. Many of them can be considerably concentrated without undergoing apparent change. When the solvent freezes completely the colloids separate, many of them in an insoluble form. They cannot be separated by decantation or filtration through paper-filters, though some can be separated by porous earthenware. To prove the existence of a "suspension," it is necessary to show that the greater part of the substance is present in the liquid in the *solid* state. That "colloidal" gold solutions give a diffusely reflected light which is elliptically polarised, are precipitated by animal charcoal, and behave towards the electric current like suspensions, is not regarded by the author as conclusive proof that they are suspensions.

F. G. D.

1699. *Influence of Salts on Solubility.* **V. Rothmund.** (Zeitschr. Phys. Chem. 33. pp. 401–414, May 18, 1900.)—The question of the diminution of the solubility of non-electrolytes in water by the addition of various salts is theoretically discussed, and some experiments with phenylthiocarbamide, made with a view to elucidate the problem, are described in detail. From the results obtained and from analogous experiments recorded by previous observers, it appears that the solubility of phenylthiocarbamide is usually greatly diminished by the presence of salts, sulphates and carbonates being the most, and nitrates the least, active in this respect. The solubility is practically uninfluenced by the nitrates of lithium and barium, and is slightly increased by ammonium nitrate. The order of activity of various salts is the same as in the case of carbon dioxide, hydrogen, nitrous oxide, and ethyl acetate. The relative change of solubility is independent of the temperature; hence it follows that the heat of solution of the substance in water is the same as in the salt solution. This seems to indicate that the decreased solubility is due not to a reaction between the substance and the dissolved salt—which would be accompanied by some heat effect—but to some action of the salt on the water.

N. L.

1700. *Solidification and Transformation of Mixtures of Optical Isomerides.* **J. H. Adriani.** (Zeitschr. Phys. Chem. 33. pp. 453–476, May 18, 1900; see also 1900, Abstracts Nos. 678, 679, 680.)—In the earlier part of the paper the

methods that have been suggested for detecting the existence of racemic compounds in the solid, liquid, and gaseous states are criticised, and it is shown that the only reliable method is that suggested by Roozeboom [see 1899, Abstract No. 1210] of examining a complete series of mixtures of the two optical isomerides. This has been done in the case of the substances described below.

(1) The melting-point curve of the dimethyl tartrates falls from 48·3° (the m.p. of the separate isomerides) to two eutectic points at 41·6° (the m.p. of a mixture containing the two isomerides in the proportion of 1 to 99 per cent.), and then rises to 89·4° in an inactive mixture of equal parts of the two isomerides. The substances thus show the characteristic behaviour of optical isomerides which give a well-defined racemic compound.

(2) Dimethyl diacetyltartrate shows a similar behaviour, but the m.p. of the racemic compound (83·8°) lies below that of the separate isomerides (104·3°); the eutectic points are at 83·4° in mixtures containing the isomerides in the proportion of 45 to 55 per cent.

(3) Mandelic acid resembles the preceding compound, the active forms melting at 132·8°, the racemic compound at 118°, whilst eutectic points occur at 113° in mixtures containing 40 and 60 per cent. of the two isomerides.

(4) The active benzoyltetrahydroquinaldines melt at 119·4°, and the racemic compound at 119·2°; the case might therefore be easily mistaken for one of pseudo-racemium, if no other mixtures were added; eutectic-points, however, occur at 117·8° in mixtures containing 35 and 65 per cent. of the isomerides.

(5) The active carvoximes melt at 72·0°, and unlike all the preceding compounds give a continuous melting-point curve, rising to a maximum at 91·4° in an inactive mixture of equal quantities of the two isomerides; the presence of a maximum melting-point suggests that the racemic compound which is stable at ordinary temperatures is also formed at the melting-point, but it is pointed out that such a maximum might also occur in a case of pseudo-racemism.

(6) The most interesting case is that of the camphoroximes, which always melt at 118·8°, whatever may be the proportion in which they are mixed The pure substances pass at 112·6° from a regular α-modification to a doubly-refracting β-modification; in mixtures of the two isomerides the transition-point is lower, and falls to a minimum at 109·4° in the case of a mixture in equal proportions. It is shown that in these cases no racemic compound is present, although one is formed at ordinary temperatures on crystallising from solution; the transition from the racemic compound to an externally compensated mixture takes place at 103°, and falls rapidly in presence of an excess of either active isomeride, but the complete curve has not yet been traced.

T. M. L.

1701. *Chemical Kinetics and Free Energy of the Reaction* $2HI + 2Ag \rightleftharpoons 2AgI + H_2$. **H. Danneel.** (Zeitschr. Phys. Chem. 33. pp. 415–444, May 18, 1900.)—The equilibrium point in the reaction was determined by shaking up silver and silver iodide in a dilute solution of hydriodic acid under a determinate atmosphere of hydrogen. The silver was used in the form of sponge, and the attainment of the equilibrium was hastened by the addition of platinum black. The equilibrium was approached from both sides, and found finally to correspond to a hydriodic acid concentration equal to 0·043 normal, for hydrogen under ordinary atmospheric pressure.

The reaction-velocity was investigated by determining in the apparatus

itself the conductivity of the solution at measured intervals. The results indicated that the reaction must be written: $H. + Ag \rightleftharpoons Ag. + H$, and not $2H. + 2Ag \rightleftharpoons 2Ag. + H_2$. Measurements of the E.M.F. of the cell $Ag/AgI - HI - HI/H_2$ did not lead to satisfactory results. F. G. D.

1702. *Spontaneous Decomposition of Thiosulphuric Acid.* **A. F. Holleman.** (Zeitschr. Phys. Chem. 33. pp. 500–501, May 18, 1900.)—H. von Oettingen [see 1900, Abstract No. 1525] has expressed the view that, on mixing a solution of a thiosulphate with an acid, formation of sodium sulphite and sulphur takes place immediately, the sulphur remaining in solution in the liquid. This view had previously been put forward and shown to be correct by the author (Recueil des trav. chim. 14. p. 71). Further, the author criticises v. Oettingen's conclusion that the decomposition of thiosulphuric acid is due to the action of the H ions on the S_2O_3 ions, and maintains, as was stated in his paper, that the decomposition may take place among the non-ionised molecules of the acid.

T. H. P.

1703. *Boiling-Point Curves.* **C. L. Speyers.** (Amer. Journ. Sci. 9. pp. 341–344, May, 1900.)—The reduction of the vapour pressure of the constituents of various liquid mixtures has been employed to determine the molecular weights of the liquids. The author now shows that, knowing the molecular aggregations of the constituents in a homogeneous mixture of two liquids, it is possible to plot the boiling-point curve of such a mixture. The equation employed is $n/(N+n)=(p-p')/p$, where $p-p'$ is the diminution in vapour pressure produced by the addition of n molecules of one liquid to N molecules of the other. For a mixture of carbon tetrachloride and benzene, the boiling-point curve for a pressure of 760 mm. of mercury is obtained as follows: The molecular weights of these liquids being probably normal in the mixture, we have $N+n=100$, and the above equation becomes a straight line for each constituent and the vapour pressure curve of the mixture is a straight line having the vapour pressures of the two pure constituents for its terminals, the composition of the mixture being denoted in molecular percentages by the abscissæ. The vapour pressures of the two liquids are at 81° both above, and at 76° both below, 760 mm., so that the boiling-point of the mixture lies between 76° and 81°, and the points where the horizontal pressure-line of 760 mm. cuts the vapour pressure curves for the different temperatures between 76° and 81° are points on the boiling-point curve of the mixture. The curve agrees well with that determined experimentally by Haywood. The same is the case for mixtures of chloroform and carbon tetrachloride and of benzene and chloroform. With a mixture of benzene and ethyl alcohol, in which Lehfeldt has shown that both components have complex molecular weights, the boiling-point falls rapidly until the molecular percentage of ethyl alcohol reaches about 10, after which the curve runs for some distance approximately parallel to the axis of abscissæ, and finally rises sharply to the boiling-point of the alcohol.

When the two constituents of a homogeneous liquid mixture have normal molecular weights for all concentrations, the boiling-point curve will be a straight line, when $dp_2/dt_2 = dp_1/dt_1$, p_1 and p_2 being the vapour pressures of the constituents at the temperatures t_1 and t_2. If, however, $dp_2/dt_2 > dp_1/dt_1$, then the boiling-point curve is convex or concave towards the axis of abscissæ according as p_2 is greater or less than p_1. Only when at least one of the constituents of a liquid mixture has an abnormal molecular weight can the mixture have a minimum boiling-point, and this is in general the case when neither liquid has the normal molecular weight in the mixture.

T. H. P.

1704. *Isothermals and Isochors for Dissociation Reactions.* **K. Ikeda.** (Zeitschr. Phys. Chem. 33. pp. 287–294, May 2, 1900.)—The equations $(\partial/\partial T)\log r = -s/RT^2$ and $(\partial/\partial T)\log K = q/RT^2$ are determined by consideration of isothermal cyclical processes applied to a solution contained in a cylinder which is separated from other cylinders by diaphragms that are permeable by one or the other or both of its components. Here r denotes the ratio of the osmotic pressures of a component in an ideal and in the actual solution, the ideal solution containing the other component only in negligible quantity; s the heat given out on passage of a molecule of this component from the actual to the ideal solution; K a relation between the concentrations of the components which is constant at constant temperature; q the heat of transformation. R. E. B.

1705. *Determination of the Transition-point of Monotropic-dimorphous Substances.* **R. Schenck.** (Zeitschr. Phys. Chem. 33. pp. 445–452, May 18, 1900.)—In monotropic substances the transition-point lies above the melting-point, so that one form is always labile and the other always stable; the labile form has the lower melting-point, and when fused may resolidify to crystals of the stable form. Enantiotropic substances can be converted into monotropic substances if the melting-point is lowered below the transition-point by adding a foreign substance (Schenck and Schneider, Zeitschr. Phys. Chem. 29. p. 546, 1899); the lowering of the melting-point of each form is proportional to the proportion of the substance added, and the two melting-point lines intersect in the transition-point. In monotropic substances the transition-point cannot be realised experimentally, but in some cases it is possible to plot the melting-point curves of both modifications for successive additions of a second substance, and their point of intersection can be determined by exterpolation. If U is the transition-point and S S′ are the melting-points of the two forms, then $\frac{U-S}{U-S'} = \frac{\Delta}{\Delta'}$ where Δ, Δ' are the depression constants for the two forms. In the case of *m*-nitro-*p*-acet-toluid the stable white modification melts at 93·32, and has $\Delta = 87{\cdot}03$, whilst the yellow labile modification melts at 91·58°, and has $\Delta' = 99{\cdot}03$; the transition-point is then calculated to be 105·9°; the added substance was in this case methyl oxalate. In the case of *m*-chloronitrobenzene (m.p.'s 44·2° and 23·7°), dinitrochlorobenzene, *p*-tolylphenylketone and triphenylmethane, the labile modification was too sensitive to allow of the determination of a depression-constant. In the case of monochloracetic acid (m.p.'s 56·3 and 61·5°), the two depression constants did not differ appreciably, showing that the heat of the transformation is very small, or the transition-point distant. T. M. L.

1706. *Solubility of a Mixture of Salts having a Common Ion.* **C. Touren.** (Comptes Rendus, 130. pp. 1252–1254, May 7, 1900.)—The author finds from his solubility measurements that KCl and KBr form isomorphous mixtures. F. G. D.

1707. *Cryoscopic Behaviour of Nitro-derivatives in Formic Acid Solution.* **G. Bruni** and **P. Berti.** (Accad. Lincei, Atti, 9. pp. 273–279, April 22, 1900.)—On determining the freezing-point depressions of formic acid, solutions of nitro-, dinitro-, and trinitro-benzene, trinitrotoluene, picryl chloride, picric acid, methyl picrate, *p*-nitrobenzoyl chloride, nitromethane, nitroethane, and chloropicrin, the authors find that, whilst the aromatic nitro-derivatives all show more or less dissociation, the fatty compounds

exhibit quite normal cryoscopic behaviour. Picric acid is dissociated to about the same extent as its methyl salt, and as the other polynitro-derivatives; so that the degree of dissociation is not influenced by the presence of hydroxyl, but tends to increase with the number of electro-negative groups in the molecule. The presence of small quantities of water is found to be without effect on the dissociating power of formic acid. The dissociation of nitro-compounds in formic acid solution may be explained by either of the hypotheses: (1) The nitro-group may be converted into the isonitro-group >NOOH, which would be susceptible of ionisation; but in benzene derivatives this conversion would not take place readily, as the iso-group would be joined to two different carbon atoms, whilst in fatty compounds, where the formation of the isonitro-group is easy, no dissociation occurs. (2) The formic acid may unite directly with the nitro-derivative forming a compound, R.NO(OH)(COOH), capable of dissociating; addition compounds analogous to these have been obtained by the action of methyl alcohol on trinitrotoluene and by the addition of potassium cyanide to trinitrobenzene. The second of these hypotheses is the more probable. T. H. P.

1708. *Reversibility of Voltaic Cells.* **T. S. Moore.** (Phil. Mag. 49. pp. 491–496, May, 1900. Paper read before the Physical Society of London.) —The reversibility of cells of the Daniell type was tested by measuring E.M.F. and potential difference—(1) when the cells were supplying a small current, (2) when a small reverse current was caused to flow by a known E.M.F. The cells examined were copper-zinc and copper-cadmium cells, with sulphates and chlorides of the metals. The internal resistance was found to be practically the same when calculated from these two sets of readings, thus indicating reversibility. Tests of a Clark cell did not give such good results, probably owing to the fact that a relatively large current had to be used. W. R. C.

1709. *Temperature-Coefficient of the Lead Accumulator.* **F. Dolezalek.** (Zeitschr. Elektrochem. 6. pp. 517–519, April 19, 1900.)—From the Helmholtz equation, $\frac{\partial E}{\partial T} = \frac{E}{T} - \frac{U}{23073T}$, and the relation $E = 1{\cdot}92 + 0{\cdot}15 \log_{10} c$ the author deduces the equation—

$$\frac{\partial E}{\partial T} = 0{\cdot}52 \log_{10} c + \text{const. (in millivolts)},$$

which holds for 18° C., and connects the temperature-coefficient of the E.M.F. of an accumulator with the concentration (in grm.-mols. per litre) of the acid. For small concentrations (as in the present case) U is practically independent of the concentration, so that the second term on the right-hand side is a constant. The relation holds from $c = 0{\cdot}1$ to $c = 0{\cdot}0005$. According to this the value of $\frac{\partial E}{\partial T}$ must assume large negative values for small values of c.

From his experiments the author finds that the temperature-coefficient sinks rapidly for values of $c < 2$, becoming zero for $c = 0{\cdot}70$. It is, therefore, positive or negative according to the concentration of the acid.

From Streintz's measurements of the heat-evolution in a working cell the author calculates (for several concentrations of acid) the values of $\frac{\partial E}{\partial T}$, and finds a moderate agreement with his observed values. He shows that for very dilute acid the E.M.F. is a linear function of temperature, and points out the efficiency of such an accumulator as a thermo-element

(for $c = 0.0005$, a voltage of 0·6 for 90° C. temperature-difference). The great dilution of the acid would, however, render such an arrangement commercially useless. F. G. D.

1710. *Liquid Ammonia.* **C. Frenzel.** (Zeitschr. Elektrochem. 6. pp. 477–480, March 22; 485–489, March 29; 493–500, April 5, 1900.)—The experiments of Cady [see 1898, Abstract No. 188] on the electrolytic conductivity of liquid ammonia and of solutions of various salts in it, although carried out with a very impure commercial product containing moisture, show that liquefied ammonia possesses a very considerable dissociating power. The author, using ammonia carefully purified by distillation and recondensation, finds for the conductivity the value, in ohm^{-1} $cm.^{-1}$ units, 1.88×10^{-7} at $-79.8°$ and 1.47×10^{-7} at $-78.6°$. By adding water to liquid ammonia, a considerable increase in its conductivity is brought about, the addition of 2·8 milligrammes of water to about 4 cubic centimetres of liquefied ammonia raising the conductivity at $-60°$ from 8·549 to 19·96 ($\times 10^{-7}$); this increase is much less than would be expected on the assumption that all the added water exists in the solution as ammonium hydroxide. Taking the conductivity at $-60°$ as the unit, the mean increase of conductivity per degree between about $-7.93°$ and $-44.2°$ is 1·9 per cent. In the case of impure and hence better conducting specimens of ammonia, this temperature coefficient is found to decrease as the conductivity increases; in this respect the close analogy to water is borne out. On studying the relation between the polarisation E.M.F. at the anode and the P.D. for approximately normal solutions of potassium nitrate, ammonium chloride and potassium ethyl sulphate in liquid ammonia, the author finds that for each of these salts the curve connecting the values of the quantities named shows three definite points of change, corresponding with E.M.F.'s of about 0·48, 0·66, and 0·78 volts; in the case of ammonium chloride these points are much less distinctly marked than with the other two salts. These characteristic changes in the curves must be due to the electrolytic dissociation of the ammonia molecule, and confirm the supposition that ammonia acts as a weak acid containing the anions NH_2, NH, and N. At higher voltages (1·08 to 1·15) there appears another point of decomposition, due to the anion of the dissolved substance. The curves obtained for ammonia containing small proportions of water also show characteristic points, but the latter are not nearly so conspicuous as with the salt solutions. This confirms the view that the added water for the most part remains as such in the solution, only a very small quantity being converted into ammonium hydroxide. It is also probable that the hydroxide itself is a very strong base comparable with the alkalis, the weak basic character of aqueous ammonia solutions being due to a considerable proportion of the hydroxide being decomposed into NH_3 and H_2O. On studying the kathode polarisation, it is found that the curves show a sharp change of direction at a voltage of about 0·1, owing to the presence of hydrogen ions. T. H. P.

1711. *Electrical Conductivity of Liquid Ammonia Solutions.* **E. C. Franklin** and **C. A. Kraus.** (Amer. Chem. Journ. 23. pp. 277–313, April, 1900; *cf.* Cady, Journ. Phys. Chem. 1. p. 707 1897.)—The ammonia is purified by distilling from a cylinder in which it is dried by means of sodium, into a receiver of special form; an essential feature in the purification is the filtration of the gas through asbestos which has been dried by prolonged heating; if this is omitted the distilled ammonia is always coloured blue by traces of sodium carried over in the distillation. The purity of the ammonia

was determined by means of conductivity measurements, and for this purpose platinum wires were sealed into the receiver; the specific conductivity of the ammonia was readily reduced below $0{\cdot}01 \times 10^{-6}$, and did not increase when kept for some hours in the receiver, showing that ammonia, unlike water, has no action on the glass, but increased to about $0{\cdot}1 \times 10^{-6}$ in the transference to the resistance cell.

Solutions of binary salts in liquid ammonia show a remarkably great molecular conductivity, the limiting values in liquid ammonia being more than twice as great as those in aqueous solution at 18°, only slightly less than those in aqueous solutions at 100°, and far greater than those in any other known solvent. Liquid ammonia has, however, a very low dielectric constant, and the dissociation constant is correspondingly low; a degree of dissociation equal to that in an aqueous solution is only reached at a dilution about a hundred times as great, and whilst the limit in aqueous solution is practically reached at a dilution of 1,000 to 5,000 litres, that in liquid ammonia is not approached until a dilution of 25,000 or 50,000 litres is reached. The high values of the molecular conductivity must therefore be due to a very great ion-mobility. Ostwald's law holds approximately for solutions in liquid ammonia. In addition to the salts examined, which included some, such as silver iodide, which are insoluble in water, a number of organic nitro-compounds and amides were found to give conducting solutions; it is of interest to note that the amides bear the same relationship to ammonia as the acids to water, whilst sodamide, the analogue in the ammonia series of caustic soda, also gives conducting solutions.

The statement of Cady is confirmed that solutions of the alkali metals in liquid ammonia conduct without any visible decomposition. T. M. L.

1712. *Electrochemical Equivalent of Carbon.* **H. C. Pease.** (Journ. Phys. Chem. 4. pp. 38–40, Jan., 1900.)—The author has attempted to determine the electrochemical equivalent of carbon by using a carbon as an anode in the electrolysis of fused caustic potash, iron being used for the kathode. The loss of weight was determined after careful washing and drying of the anode, special precautions being taken to ensure that the caustic potash had really been removed. In five experiments the equivalent weight varied from 3·14 to 3·66; the number of coulombs was approximately the same in each experiment, the time, and therefore the current, being varied. The author concludes that the true value is 3·0. W. R. C.

1713. *Faraday's Law applied to Fused Salts.* **A. Helfenstein.** (Zeitschr. Anorg. Chem. 23. pp. 255–316, March 31, 1900.)—A number of fused chlorides, bromides, and iodides were examined, and were found to give deviations from Faraday's law amounting sometimes to as much as 100 per cent. The chief source of error is due to the diffusion of the metal and halogen through the electrolyte until recombination occurs, and this can only be avoided by using a porcelain diaphragm. The error due to solubility of the metal in the electrolyte can be overcome by previously saturating it at the temperature of electrolysis. The error due to diffusion of metal vapour into the air can be avoided by enclosing the kathode. T. M. L.

1714. *Electrolysis of the Alkali Salts of Organic Acids.* **J. Petersen.** (Zeitschr. Phys. Chem. 33. pp. 99–120, April 3; 295–325, May 2; and 698–720, June 15, 1900.)—A detailed study of the products of electrolysis of a number of acids of the acetic and oxalic series, including formic, acetic, propionic, butyric, isobutyric, valeric, isovaleric, trimethyl-acetic, caproic, oxalic, malo-

nic, succinic, isosuccinic, pyrotartaric, ethylmalonic, and sebacic acids. The acids were used in the form of their potassium salts and the electrolyses carried out, as a rule, in slightly acid solutions at 0° and between platinum electrodes. In many cases the effect of variations in the concentration and in the current was ascertained. The results obtained are chiefly of chemical interest, and do not admit of useful abstraction. N. L.

1715. *Electrolytic Synthesis of Organic Substances. Part I.* **O. Dony-Hénault.** (Zeitschr. Elektrochem. 6. pp. 533–543, May 3, 1900.)—In the electro-synthesis of organic compounds two classes of reactions are to be distinguished: those in which the compound is formed by the interaction of the ions, as in the formation of ethane by the electrolysis of acetic acid, and those in which the liberated ions act on a non-electrolyte in the vicinity of one of the electrodes, as in the reduction of nitrobenzene to aniline. This paper is the first of a series in which it is proposed to study reactions of the second class more systematically than has hitherto been done. Stress is laid on the importance of ascertaining the exact experimental conditions favourable to each synthesis, and the E.M.F. at the working electrode is considered to be of more value than the current density as a measure of the chemical action of the ions. Every organic compound capable of entering into reaction with the liberated ions acts as a depolariser, and the requisite condition for the decrease of potential is that the reaction shall take place with loss of free energy. Thus the electrolytic decomposition point for chlorine ions in normal hydrochloric acid is 1·31 volts (compared with hydrogen), whilst in the presence of phenol the required E.M.F. is reduced to 0·9 volt. Accordingly, as some preliminary experiments have already indicated, the quantitative conversion of phenol into one or more chlorine derivatives should be made possible by careful regulation of the E.M.F. Similar observations apply to the preparation of bromine derivatives of phenol. A series of experiments, described in detail in the paper, has been carried out on the electrolysis of dilute sulphuric acid in the presence of methyl and ethyl alcohols. The results show that by keeping the anode potential between 1·3 and 1·66 volts throughout the electrolysis a quantitative conversion of ethyl alcohol into aldehyde is effected; with higher potentials the yield of aldehyde diminishes, and acetic acid and ethyl hydrogen sulphate are formed. In the case of methyl alcohol the author confirms Renard's observation that formaldehyde is not produced, the primary oxidation product being probably methylal. The paper concludes with some remarks on the analogy between chemical and electrochemical modes of oxidation, and it is shown that the limited oxidation of alcohol to aldehyde can be effected chemically by means of cupric oxide or lead peroxide in alkaline solution.
N. L.

1716. *Electrolytic Etching and Engraving.* **J. Rieder.** (Elekt. Runds. 17. pp. 139–140, April 15; and 161–163, May 15, 1900.)—In this process the article to be etched or engraved is made the anode in an electrolytic bath. In order to produce designs in relief without repeated "stopping off" with an insulating coating of the parts which are not to be etched, the author produces a liquid surface of the reversed form of the raised design to be obtained. This surface is formed by a plaster of Paris mould of the object to be copied, the back of this mould dipping into a solution of ammonium chloride, in which the kathode dips. The steel plate to be etched rests on the top of the moulded surface of the plaster of Paris block above the level of the liquid

and forms the anode. On passing the current, the metal is gradually eaten away until it touches the whole of the moulded surface of the plaster of Paris. In order to enable it to be determined when the etching is complete, and to permit the particles of carbon set free from the dissolved steel to be brushed away, the author has designed a machine whereby the steel plate can be raised from the plaster of Paris, brushed and replaced exactly in its original position; it is then left in contact for 15 seconds, then raised and brushed, and so on. The current, for a steel plate 200 × 300 mm., increases up to 50 amperes at 12 to 15 volts. Further details of the process and the machine are given in the original paper, which is illustrated. C. K. F.

1717. *Electrolytic Preparation of Oxygen Salts of the Halogens.* **P. Imhoff.** (Zeitschr. Elektrochem. 6. pp. 550–553, May 10, 1900.) German Patent, No. 110420, 1898.—The decomposition of the water, or of the hydrates formed from the water, causes a considerable loss of current in many electro-chemical processes, and in the German Patent No. 66089 the inventor has sought to diminish this loss in the case of the decomposition of sodium chloride by addition of aluminium oxide to the electrolyte. This oxide forms sodium aluminate with sodium hydrate, and as the decomposition value of the aluminate is higher than that of the hydrate, the sodium is withdrawn from the action of the current.

In the electrolytic preparation of chlorates, not only the first formed hydrate, but the intermediate and final products share in the decomposition caused by the passage of the current through the electrolyte. The principle of the author's method for diminishing the loss in this case is the same; but the oxide added to the electrolyte must possess both acid and basic properties. As examples of such oxides, alumina, silicon dioxide, and boron trioxide are named. Figures are given which show that the addition of the first to a chloride solution increased the current efficiency, whether hydrate, hypochlorite, or chlorate, was considered. For a solution containing 15–25 per cent. potassium chloride, and 1·5 per cent. free alkali, the author recommends the addition of 2 per cent. alumina.

A method for determining the work performed by each portion of the current in its passage through such an electrolyte is described, this being based on Oettel's method of measuring and analysing the gases evolved at the electrodes of the cell. The results of the author's investigations are given in three tables. These show that when alumina and potassium chromate are added to the electrolyte, there is a reduction in the volume of the gases arising from decomposition of the water, or of the hydrates, and an increase of current efficiency as regards the production of chlorate. J. B. C. K.

1718. *Becker's Electrolyser for Alkalies.* (Électricien, 19. pp. 316–318, May 19, 1900.)—This electrolyser is designed for the production of metals from their fused salts or oxides, and is especially applied to the production of sodium and magnesium.

The electrolyser consists of a metallic vessel, provided at its base with a tubular aperture through which the kathode enters the vessel. The joint between the kathode and this tube is made by cooling and solidifying the salt undergoing electrolysis, at this point. The kathode is constructed of metal, and should be conical in form, to facilitate the floating upward of the globules of metal which collect upon it. Another form of kathode is described. The anode should be of carbon or of metal, according to the composition of the electrolyte. It is made annular in form, and surrounds the kathode.

The connection with the current supply is made by numerous wires attached to its external surface. The apparatus is completed by a flat cone-shaped cover, which is fixed just below the surface of the molten electrolyte over the kathode, and is designed to receive and protect from atmospheric action the metal separated at the kathode. The upper part of this collector is exposed to the air, and should it still become too heated, it can be cooled by artificial means. It is connected to the negative pole of the dynamo through a resistance. It thus acts as an auxiliary kathode, and any metal collecting underneath it is kept negatively charged until passed from the cell by the side delivery tube.

For the preparation of metallic sodium a mixture of sodium hydrate and sodium carbonate is recommended as electrolyte. The form of electrolyser described above is patented in Europe and in the States. Two cells, the one designed to utilise a current of 500 amperes, and the other a current of 1,000 amperes, are installed at the *Affinerie Electro-metallurgique de Bellegarde sur Valserine.* Three diagrams illustrate the article. J. B. C. K.

1719. *Electromagnetic Ore Dressing.* **E. Langguth.** (Zeitschr. Elektrochem. 6. pp. 500–506, April 5, 1900.)—This paper deals with the principles underlying the magnetic separation and concentration of minerals. The author explains the action as the result of the respective influence of weight, motion, and less or greater magnetism of the particles of ore. He does not agree with the recently advanced classification of weak and strong magnetic separation. Two main features are to be considered for rational separation: (1) Production of strong magnets with least expenditure of energy. (2) Separation of magnetic and non-magnetic products into divergent paths with the least amount of power. Electromagnets are the only important form used at present.

The conditions best suited for utilising magnetic energy for the purpose of separation are briefly stated to be: (1) Generation of magnetic currents of the least possible potential and the greatest density; (2) The passage of the material to be operated upon at the least distance from the magnetic poles.

Although theoretically simple, these conditions are not brought into effect in the majority of electro-magnetic separators. Very narrow fields are awkward for separation, and, on the other hand, crushing to uniform grains is not easily accomplished.

Theoretically the diameter of the grain need not exceed the width of the field, but actually at least twice the distance is required. Direct contact of the particles of ore with the bare poles is hardly feasible owing to the manner in which the ore has to be conveyed. As the material is attracted with variable intensity by the two poles, actual experiments must decide the exact distance at which it must be passed.

Experiments are then given in which the ratios between motion and magnetism are altered. The apparatus used was the ore separator of the Mechernicher Bergwerks-Aktienvereins. Distance of poles 7 mm., and material passed at variable speed 1 mm. from active pole working on a belt. Power expended 1 kilowatt, thus ensuring a very concentrated field between the poles. The artificial mixture of material consisted of same sized grains of magnetite (strongly magnetic), rhodonite (medium magnetic), and zincblende (feebly magnetic). The results obtained were as follows: (1) Velocity of belt 100 m. per minute, magnetite alone affected. (2) 70 m. per minute, rhodonite partially attracted and zincblende not at all. (3) 50 m. per minute, rhodonite completely separated, but not zincblende. (4) 40 m., partial action

upon zincblende. (5) 80 m., zincblende entirely attracted. On lowering speed to 5 m. per minute the zincblende could still be magnetised with an expenditure of 20 watts.

The author therefore draws attention to the importance of adjusting the rate of travel in accordance with magnetic properties. Reference is then made to the problem of material falling vertically in the neighbourhood of a magnet, and the conclusion arrived at is that this method must be wasteful from the point of view of power expenditure unless efficient means are found of suitably diminishing the speed by obstacles. The author concludes by stating that the conditions underlying the problem of electromagnetic separation are, therefore—(1) Generation of magnetic currents of least intensity and greatest density ; (2) Passage of the material to be operated upon through the magnetic field uniformly at the least possible distance from the active separative pole ; (3) Variable external movement of the material under treatment ; (4) Separation in homogeneous magnetic fields. O. J. S.

REFERENCES.

1720. *Electrical Energy by Oxidation of Carbon.* **W. E. Case.** (Elect. World and Engineer, 34. pp. 121–123, 1899.)—The author shows that aqueous solutions of ferric chloride are reduced by carbon in the cold. He also describes experiments with cells in which ferric chloride was used as the electrolyte, and carbon as a reducer. The E.M.F. was small. W. R. C.

1721. *Liquid Hydrogen.* **J. Dewar.** (Roy. Inst., Proc. pp. 1–14, Jan. 20. 1899. Also Chem. News, 81. pp. 137–139, March 23, and 148–151, March 30, 1900.)—A lecture given at the Royal Institution, recapitulating the researches of the author and others on the liquefaction of hydrogen. [See Abstracts Nos. 1069 (1898), 668, and 1489 (1899).] N. L.

1722. *Carbonic Anhydride of the Atmosphere.* **E. A. Letts** and **R. F. Blake.** (Roy. Dublin Soc., Proc. 9. pp. 107–229, April, 1900.)—This paper, which is too long for a complete Abstract to be given, treats exhaustively, under the following headings, of the carbonic anhydride of the atmosphere : (1) Introduction and Methods of Determination : a historical account of all the various methods proposed for the estimation of the quantity of carbonic anhydride in the air. (2) The author's improvements on Pettenkofer's process. (3) Action of baryta water on glass, and the effect of soluble silicates on the phenolphthalein colour reaction. (4) Amount of the anhydride in the air ; and (5) Causes of variations in this amount. There are two appendices, the first treating of ground air and its relations to atmospheric carbonic anhydride ; and the second, by W. Caldwell, containing a comparison of the results of the determination of carbonic anhydride by Pettenkofer's process with those given by the author's modification of that process. T. H. P.

1723. *Electro-deposition of Chromium.* **S. Cowper-Coles.** (Chem. News, 81. pp. 16–18, Jan. 12, 1900. Read before the Institution of Mining and Metallurgy, Dec. 20, 1899.)—A paper on the same lines as those previously noticed in Abstract No. 340 (1899). N. L.

1724. *Discharge Device for Electrical Furnaces.* (Elekt. Runds. 17. pp. 114–115, March 1, 1900.)—This is a description of a tapping device for an electrical furnace, having for its object continuity, exclusion of air, and also the cooling of the finished product before leaving the furnace. O. J. S.

1725. *Formation of Carbides.* **A. A. Beadle.** (Elect. Rev. 46. pp. 611–613, April 13, 1900.)—General consideration of formation of carbides in the electric furnace. A summary of the properties of a large number of carbides is given. W. R. C.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

1726. *Combined Refuse Destructors and Power Plants.* **C. N. Russell.** (Inst. Civ. Engin., Proc. 139. pp. 181–201; Discussion, pp. 202–254, March, 1900.)—A distinction is drawn between refuse destructors designed to destroy garbage cheaply and effectively, and the economical raising of steam on a large scale by the heat generated in destructors.

The methods of dealing with refuse are classed under three heads: (i) Cheap disposal; (ii) Disposal from a sanitary point of view; (iii) Disposal with a view to steam raising.

The results obtained from Oldham, Warrington, Cambridge, and other places, are stated to have demonstrated (i) that a considerable amount of energy can be obtained from refuse furnaces, and (ii) that refuse in each locality has a fairly definite calorific value. The amount of steam raised per pound of refuse burnt shows great variations in various localities. Abroad, notably at Hamburg and Brussels, the amount of steam raised is practically negligible, and the residue nearly 100 per cent. greater than that usually found in England, where it is about 28 per cent. of the refuse.

The Shoreditch combined electricity supply works and refuse destructor is next described, and is stated to be the largest of its kind in the kingdom. The works were opened in June, 1897, the destructors being built by Manlove Alliott & Co. The destructor and boiler house is separated from the electric generating station by fireproof doors. The former contains six Babcock & Willcox boilers, each having two refuse furnaces, one placed on either side of the boiler; an ordinary coal firegrate immediately under the boiler tubes is provided as an auxiliary if required. Coal is burnt as well as refuse at these works, the calorific value of the refuse not always being equal to the demand on the amount of steam.

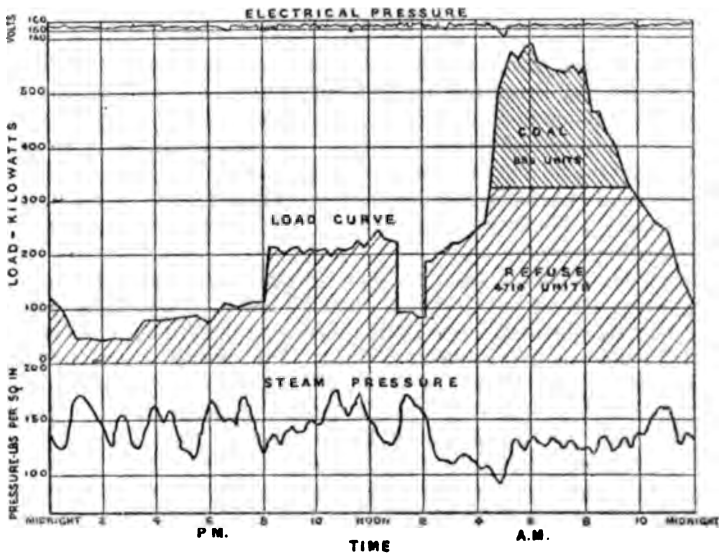
The average amount of refuse is 84 tons per day; as much as 140 tons has been received in one day. Refuse is delivered between the hours of 9 a.m. and 5 p.m. Spare storage is provided to cope with extra heavy deliveries. The lift and tip-trucks for dealing with the refuse are worked entirely by electricity, 0·52 kw. hours being expended per ton of refuse moved, this figure being arrived at from over a year's working and a total of 25,000 tons moved. The average time required to deal with a load of refuse shot into the lifts, raised to the top platform, tipped, and empty truck returned to starting-point, is nine minutes.

Each furnace is provided with both steam and forced air draught. In the author's experience the latter is found to be preferable. The air-pressure is 3 inches at the face and 1 inch in the ashpits. The temperature obtained in the furnaces often exceeds 2,000° F. The author thinks the electrical energy necessary to drive the fans is very high, and considers that there is much room for improvement in electrically-driven fans.

The feed-water is heated by a Green's Economiser to 220° F.–250° F., and is then forced into a feed thermal storage vessel (Druitt Halpin's system). This is found useful for depositing the lime in the feed-water, of which 1,828 lbs. dry weight were found after seven months. The economiser was

opened at the same time, and found to be very free from scale, deposit in the tubes being less than $\frac{1}{16}$ inch in thickness.

The author is of opinion that the feed storage system has contributed largely to the success of the plant generally, it being possible to store hot feed-water for eighteen hours out of the twenty-four.



Evaporative tests are made from time to time, of which the two following, carried out on January 10, 1899, are of interest :—

	1	2
Duration	8 a.m. to 1 p.m.	3 p.m. to 8 p.m.
Water evaporated from and at 212° F.	72,220 lbs.	108,319 lbs.
Refuse burned	75,092 lbs.	60,700 lbs.
Coal (Powell Duffryn)	nil	6,272 lbs.
Number of cells in use	10	10
Number of boilers in use	5	5
Water evaporated per lb. of refuse burned	0·96 lb.	—

The load curve for these tests is given in the accompanying figure. The abrupt drop at 1 p.m. is due to motors in factories being switched off.

Experience at Shoreditch shows that the full evaporative efficiency of coal is not obtained when burnt in conjunction with refuse.

The following is the analysis of the refuse dealt with at Shoreditch for the year ending June, 1898:—

	Tons.
Domestic refuse	23,137
Trade refuse (straw, paper, tan, market refuse, &c.	2,257
Wood chips, about	10
	25,404

The residue after passing through the furnace may be divided as follows :—

	Per cent.
Common clinker	29·0
Fine ash	2·7
Fine dust	0·5
Old tins	0·6
	32·8

The average moisture in the refuse is 20 per cent.

Artificial paving-stones are manufactured from the clinker, consisting of 2¼ parts of ground clinker to 1 of Portland cement, ground very fine and pressed at 1¼ tons per square inch. A sample slab, when supported at its ends, sustained a weight of 2,221 lbs. before breaking.

The cost per ton ot destroying refuse works out to 2s. 4·89d. for the year ending June 30, 1898, and 2s. 6·9d. for the year ending June 30, 1899. This includes the wages of four furnace men, three top men, and one foreman, supervision and clerical staff, cleaners and yardmen, repairs, stores, &c.

The amount of electrical energy absorbed in burning and handling the refuse over one year's working is—

Electric fans	4·0 units per ton.
Electric lifts and tipping trucks	0·5 „
Electric lighting	0·48 „

Gross results taken over a year's working are :—

Total energy metered to consumers, including 131,140 units supplied to destructor	1,031,348 units
Coal consumed, value £1,308 14s. 8d.	1,844 tons
Refuse burnt	26,201 tons

The results of experience gained at Shoreditch are summed up as follows: (1) That domestic refuse in London has an average calorific value equal to evaporating 0·99 lb. water per lb. of refuse burnt. (2) That in London it can be destroyed for 2s. 5d., which is stated to be less than it would cost to barge away. (3) That the total amount of power to be obtained per annum from the whole of the refuse in London, if burned in suitable furnaces, would amount to about 133,000,000 B.H.P. hours. (4) That a combination of one boiler and two furnaces may be relied upon to evaporate 2,888 lbs. water per hour from and at 212° F. at a pressure of 200 lbs. per square inch with refuse as a fuel.

An interesting appendix is given, in which the details and results of other destructor plants in various parts are summarised.

In the discussion **S. H. Terry** remarked that in the case of forced draught some means of allowing the dust to subside should be employed. He submitted drawings of an arrangement he had devised for effecting this some years since, which is based on the principle of reducing the velocity of the gases by enlarging the flue. **F. W. Webb** said that between 4,000,000 and 5,000,000 bricks were made yearly at Crewe of refuse clay from the works. **C. Jones** considered that a high temperature in the furnace did away with necessity for a cremator. **A. H. Preece** analysed the author's figures, and pointed out that the refuse was equivalent to coal at 25s. per ton. He advocated the use of destructors as much as any one, but there was no question of getting electricity for nothing. **F. Watson** said that high temperatures always produced the hardest clinker. **E. C. de Segundo** took exception to the author's view that 1 lb. of ordinary London refuse could be relied on to

[illegible]

[illegible] friction and inertia and [illegible] which he calls the "[illegible] If it were possible to do away with all internal and external [illegible] the [illegible] sensitiveness would be—

$$\frac{2}{\pi}\sqrt{\frac{f}{M}}$$

where [illegible] the [illegible] sensitiveness, f is the force-power, and M the [illegible] of the external inertia or masses.

A. S.

GAS AND OIL ENGINES.

1729. *Monarch Gas Engine.* (Automotor Journal, 4. pp. 391–393, May, 1900.)—A two-stroke engine in which the explosive mixture is drawn by the piston into the crank-chamber during the compression stroke of the working cylinder, is compressed in the crank-chamber during the firing stroke, and is allowed to pass into the working cylinder during a part of the exhaust period. The piston uncovers an exhaust port before the end of its working stroke, and immediately afterwards uncovers an inlet port leading from the crank-chamber. The piston is provided with a baffle plate, which reduces the tendency of the incoming charge to pass out of the exhaust port. Ignition is effected by means of an electric spark inside the combustion chamber. A low-tension electric system is employed, the spark being produced between a fixed insulated contact piece in the cylinder head and a rocking arm, which passes through the wall of the cylinder, and which is operated by a slow make and quick break mechanism. The ignition device is worked by an eccentric upon the crank-shaft of the engine, and is so arranged that three different periods of ignition, during the compression stroke of the engine, are provided for; either of these timing positions can be used, according to the engine speed required. A battery, or a magneto-machine, is connected in series with an iron-cored solenoid and with the steel contact pieces in the combustion chamber. The motors, of which detail drawings are given, are fitted with fly-wheel governors which regulate the amount of the explosive charge drawn into the crank-chamber, and are also fitted, for launch work, with an exhaust-pipe cooling device; the latter consists of a pipe, leading from the cylinder water-jacket, which delivers a constant flow of water into the exhaust pipe. Various sizes of these motors are made, from 1 H.P. to 12 H.P. (three-cylinder). A single cylinder motor, having 3½-inch bore and 3¼-inch stroke, develops 1·2 B.H.P. when running at 600 r.p.m. A. G. N.

1730. *Blowing Engine Worked by Blast Furnace Gas.* **A. Greiner.** (Mech. Eng. 5. pp. 728–729, May 26, 1900. Abstract of a paper read before the Iron and Steel Institute, May, 1900.)—This paper gives a short abstract of results obtained at the Cockerill Works with the first blowing engine worked by blast furnace gas. A brake test of the engine was made, and the mean power during the day was 575 H.P., the speed being 80 r.p.m. and I.H.P. about 700. Next day the brake was taken off, and the engine run as a blowing engine, the mean power developed being 725 H.P. The calorific value of the gases was on the average 984 calories per cubic metre as determined by Witz's calorimetric bomb, 860 as measured by Junker's calorimeter. The heat was expended as follows: 30 per cent. converted into work in the cylinder, 50 per cent. carried off by the water-jacket, and 20 per cent. carried off by the escaping gas. Drawings are already in hand for three 1,200 H.P. blowing engines; while of 48 gas engines of this type at present ordered three are for works which could not have been established if the new invention had not been brought into effect, *i.e.*, in situations where water is entirely absent.

A. S.

1731. *Dawson Oil Engine.* (Automotor Journal, 4. pp. 321–324, April, 1900.)—A four-stroke motor in which a compressed-air system is incorporated into the engine itself in order (1) to start it automatically in either direction, by utilising air which has previously been compressed, (2) to recharge a compressed-air reservoir, (3) to scavenge the working cylinder during the exhaust

stroke, and (4) to increase and vary the amount of explosive charge which is taken into the engine cylinder. The cylinder is nearly twice the ordinary length and contains a double piston; the back end is of one diameter and the front portion is of a larger diameter. Each part of the piston fits into, and works in its respective portion of the cylinder. The smaller cylinder and piston constitute the oil engine proper, while the annular space between the smaller piston and the larger cylinder enables that portion of the motor to be utilised either as an air pump or as a pneumatic engine. A passage leading from the rear end of the larger cylinder is provided with a slide-valve, which is controlled by an eccentric as in a steam engine; the eccentric is mounted upon a shaft in such a manner that it can be made to assume a concentric position or to secure a reversing action upon the slide-valve, by being returned to an eccentric position, but at an angle of 180° from its original position. The slide-valve controls communication between the cylindrical annular space and a valve chest, which is connected to an air reservoir and to a port leading into the working cylinder. The valve-chest contains two slide-valves, which are connected together and which are operated by hand; the one valve controls the passage from the air cylinder into the valve-chest, and the other controls a port leading into the working-cylinder. The two valves alternatively open or close one or other, or close both, of the passages which they control, but the former also acts as a non-return valve from the valve-chest to the air cylinder, when it is normally closed. An air reservoir is provided, and this communicates with the valve-chest by means of a pipe containing a non-return valve. The non-return valve can be opened by a hand lever when it is desired to start the engine with compressed air, and the reservoir is fitted with a safety valve. The oil-motor cylinder is fitted in much the usual way, with inlet and exhaust valves and with a variably-timed high-tension electric ignition device; the petrol is fed to the mixing chamber by a pump, and the cams are fitted in duplicates so that one set allows the engine to work in each direction. The motor is fitted with three complete cylinders, in order to avoid dead points; it is started by admitting compressed air to the air cylinders; its working cylinders are scavenged by allowing the air, which is compressed by the larger cylinders, to pass into the working cylinder at the end of each firing stroke; the explosive charge is augmented at the end of each suction stroke in a similar manner. The working cylinders are 3½ inches in diameter, the air cylinders are 4½ inches, and the stroke is 5 inches; the air reservoir normal pressure is 60 lbs. per square inch, and it has a capacity of 7 cubic feet; the speed of the motor is from 400 to 800 r.p.m., and the B.H.P. is about 8·8 with a normal charge, and about 12·5 when fully augmented with compressed air. A. G. N.

AUTOMOBILISM.

1732. *Gardner Serpollet Steam Motor Car.* (Automotor Journal, 4. p. 341, April, 1900.)—This article describes the general arrangement of the machinery of a Serpollet car propelled by the steam motor described in Abstract No. 903 (1900). It also gives a sketch of the Serpollet oil and water-feed apparatus, the action of which is described by reference to a diagram of water and oil connections. W. W. B.

1733. *Dupressoir Motor Car.* **P. Sarrey.** (Locomotion Automobile, 7. pp. 311-318, May 17, 1900.)—This article describes a voiturette, which includes a special form of change gear constructed by Dupressoir, the different speeds being operated selectively by means of cone clutches.

The illustrations show in elevation and plan the main elements of the voiturette, and a two-speed change gear in sectional elevation. W. W. B.

1734. *Winton Petroleum Spirit Motor Car.* (Indus. and Iron, 28. p. 151, March 9, 1900.)—This article describes a petroleum spirit motor vehicle in which the departures from the most usual practice are the arrangements of petrol feed and air carburation.

The valve for admission of air to the cylinder traverses the carburetted air admission from the mixing chamber, and passes into a small dashpot cylinder, the piston of which is fixed to the end of the valve stem. The nut which fixes this piston also fixes a bent spring which carries a pointed valve; this has a seating in a petrol nozzle, which enters one side of the air admission pipe to the mixing chamber. Thus at every charge admission stroke of the motor piston, a carburetted air charge is taken from the mixing chamber, and a new charge of air and petrol admitted into the chamber. The movement of the pointed petrol valve is limited by an adjusting screw, and the dashpot forms a governor because of the automatic variation of the movement of the charge admission valve with variation of the motor piston speed. The maximum speed of the engine as controlled by this governor is adjustable by an air cock on a pipe, opening the inside of the dashpot to the atmosphere.

The electrical ignition apparatus is of the low-tension magneto type, with tappet make and break inside the charge admission port.

The engine is placed in the direction of length of the car, and drives by spur gear a countershaft having two clutch-controlled speeds, and a final drive by chain to a short pinion spindle, gearing with a spur wheel on the differential gear-box. Speeds between those of the gear at normal speed of the engine are obtained by varying the speed of the latter, all ordinary running being done by the direct driving upon the differential gear. A general arrangement of the car machinery and sections of the motor from patent drawings are given. W. W. B.

1735. *Mors Motor Car.* (Automotor Journal, 4. pp. 342–343, April, 1900. From La France Automobile.)—This is briefly descriptive of the four cylinder 10 H.P. (nominal) Mors carriage, with which recent high-speed records have been made. Diagram views of the motor and of the electrical ignition connections are given. W. W. B.

1736. *Estcourt Water Cooler.* (Automotor Journal, 4. pp. 333–335, April, 1900.)—This article describes a tubular water cooler for water-cooled motors, so arranged that the heated water rises to the upper part of the system of piping, and being cooled by radiation falls therefrom to the lower part of the system, and thus keeps up a natural circulation of the contained water. To obtain the necessary radiating surface the cooler is made larger in height than usual, and so placed in the front of the car and on the dashboard that it receives the full effect of the air current. As a supplementary means of circulation a self-acting bucket valve is placed in one of the columns carrying the cooling tubes. This valve rests upon a coiled spring of light resistance, but of sufficient strength to carry the bucket normally at a given position. In running over the roughness of an ordinary road the movements of the car are sufficient to bring into play alternately the inertia of the valve and the recoil of the spring, thus setting up movement of the water in one direction. The object of the apparatus is to dispense with either pump or fan. W. W. B.

GENERAL ELECTRICAL ENGINEERING.

1737. *Electricity Meters.* **A.** and **V. Guillet.**. (Comptes Rendus, 130. pp. 1549–1551, June 5, 1900.)—The number of oscillations of a magnetised needle within a coil traversed by a current, or of a second coil in series with the first, is proportional to the quantity of electricity passing through the coil in the same time ; this is the fundamental principle of the Boys and Blondlot quantity meters. In order to apply the method to the measurement of energy, the continuous force acting on the moving system must be replaced by an impulsive force. For this purpose the authors employ an oscillating coil suspended in a magnetic field, which may be constant (in which case the meter measures quantity), or may be proportional to the supply pressure (in which case the meter measures energy), the circuit through the moving coil being closed momentarily only.

The constant field may be produced by a magnet, while the variable field is produced by a coil connected in shunt to the supply terminals. To maintain the vibration, in the author's model the shunt coil is suspended, and makes a contact at each end of its swing ; the counting train is driven by the motion of the coil. Mathematical proofs of the theory are given. A. H. A.

1738. *Automatic Electric Signals at the Paris Exhibition.* (Engineering, 69. pp. 647–649, May 18, 1900.)—A description of I. A. Timmis's system installed by A. Lavezarri on the electric railway. This is a single line, about two miles long, and has four signalling points. The signal is of the disc type, fitted in an iron framework, closed in front with clear glass and behind with opal glass. The latter is illuminated powerfully at night. The arm consists of fine red calico on a light frame, and is operated by a small long-pull electromagnet worked with twelve Leclanché cells or five accumulators. Each signal has two electrical contacts fitted near the rails on the outer side, the first a breaking-contact, and the second, a little ahead, a making-contact. These are actuated by a striking bar, which is fixed to the train, knocking against arms or hangers belonging to these contacts. On leaving a station the train knocks open the breaking-contact, the local circuit is broken, and the signal, no longer held down by its electromagnet, goes to "danger" by gravity. This movement of the arm switches in the line circuit to the rear signal, so that as the train proceeds and knocks the making-contact a current is sent to that signal and the arm is pulled down to "line clear." Another train can thus enter the rear section. Upon leaving the second station a similar series of operations is performed by means of the striking-bar. The breaking-contact is opened, the arm rises and switches in the line circuit to the signal outside the first station, and the making-contact occurring immediately afterwards sends a current through that switch, pulling down the arm of the signal outside the first station, thus clearing the line.

A resistance comes into circuit locally at the time when the arm has been lowered in order to reduce the consumption of current for holding the arm. This economy of current is a most essential feature of the system.

The above description applies to absolute automatic working. For permissive working the connections can be altered to allow of particular places, not sections, being protected. For instance, at a curve, the breaking-contact

can be knocked over and the arm lifted as the train enters it, and the making-contact can be placed so as to operate and to permit the same signal to drop when the train leaves the curve. E. O. W.

1739. *Properties of Carbon in Electrical Work.* **Elihu Thomson.** (Elect. World and Engineer, 35. pp. 703–705, May 12, and 787–788, May 26, 1900. Abstract of a paper read before the North Eastern Section of the American Chemical Society in Boston).—The author deals seriatim with the uses of carbon for various electrical purposes. In the first place the employment of arc-lamp carbons is entered upon, and it is shown that no mixture of carbon with other substances has been successful in replacing the pure carbon. The value of carbon for electrodes for arc lamps is ascribed to its absolute infusibility and high temperature of sublimation. The latter is said to be, according to Violle, about 3,500° C. Before the volatilisation the carbon is converted into pure plumbago, and it is this that gives rise to mushroom growths on the negative carbon when the carbons are too close together.

Reference is made to the Acheson method of making graphite by passing very heavy currents of electricity through artificial carbons embedded in loose carbon. With regard to incandescent lamps, the universal use of carbon filaments is referred to, and the method of preparation and flashing the filaments is explained.

Further the employment of carbon in telephone transmitters is explained and its advantages discussed. Finally, the introduction of carbon brushes to replace metal ones on continuous-current motors is shown to have been a great boon in motors for traction purposes.

An account of a modified carbon brush, which the author has had in successful use for over 7,000 hours, is given, and the method of construction is explained. J. L. F. V.

1740. *Depreciation of Machinery.* **R. H. Smith.** (Feilden, 8. pp. 270–281, March, 1900.)—The depreciation of a machine in the course of one year is the change in the capitalised present value of its net earning power, taking into account the probable duration of its remaining life. The capitalised value of the earning value of a new machine is, if it be well chosen and skilfully placed, more than its money cost by the value of the intelligence employed in selection and placing. A mathematical expression is obtained for the depreciation of the present intrinsic and extrinsic value, and curves are plotted from which it is clear that the prevalent notion of decreasing the rate of depreciation towards the end of a machine's life is erroneous: such yearly depreciation should increase. The author contends that in a *bonâ fide* concern the selling value of the plant is altogether a wrong value to attach to machines, instead of their working value. Examples and tabular explanations are given. M. O'G.

REFERENCES.

1741. *Coal-Handling Plant at the Wandsworth Electric Lighting Station.* (Engineering, 69. p. 524, April 20, 1900.)

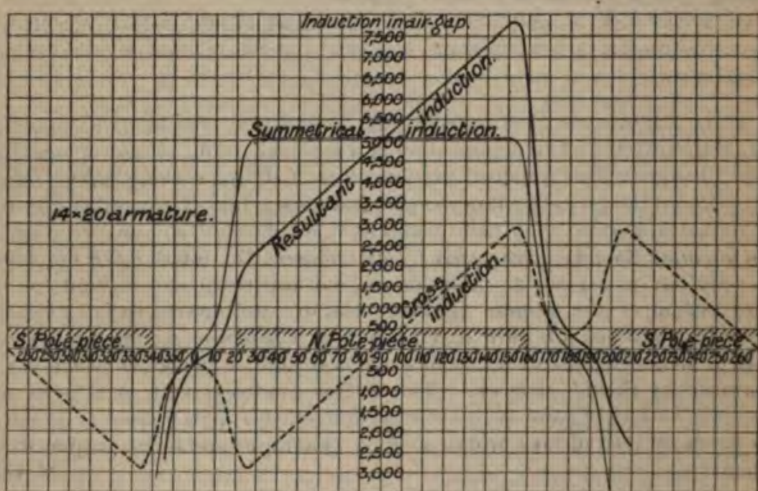
1742. *Mechanical Applications of Electricity.* **G. Richard.** (Écl. Électr. 20. pp. 241–253, and 21. pp. 361–368, 1899; 22. pp. 328–336, March 3, 1900.) *Descriptions of Sprague and Heerman and Whichello Elevator, and Slow-travelling Crane* (pp. 241–253.) The Motor Controllers of Englewood, Davis, Russell, and the Rapps Indicator (pp. 361–368). For preceding parts see 1898, Abstract No. 555, and 1899, Abstracts Nos. 744, 1250, and 1769.

GENERATORS, MOTORS, AND TRANSFORMERS.

1743. *Subdividing Dynamo P.D. by means of Choking Coils.* **A. Sengel.** (Elektrotechn. Zeitschr. 21. pp. 387–391, May 17, and 410–413, May 24, 1900.) —The author works out the theory of the various arrangements shown in the diagram of Abstract 1263 (1899). He next describes a series of experiments made with the view of testing the theoretical deductions. The results obtained show approximate agreement between the two. A. H.

1744. *Air-gap Induction in Continuous-Current Dynamos.* **C. C. Hawkins** and **R. Wightman.** (Inst. Elect. Engin., Journ. 29. pp. 436–457, April, 1900.)—Within the bore of the pole-pieces the lines may be taken as radial and uniform in density over 85 per cent. of the polar arc; for $7\frac{1}{2}$ per cent. at each end the lines begin to curve outwards and the density diminishes. Beyond the pole-tip the length of a line at any point A is $\xi(c-x)+l_g$, where c = distance on the periphery from the line of symmetry to the radius drawn to the pole tip, x = distance from the line of symmetry to the point A, l_g = air-gap, and ξ is a constant estimated from the drawing. In a two-pole armature with poles covering 120°, ξ = about 2·2.

If X_p = total ampere turns, X_g the A.T. for the double air-gap, X_a = A.T. required to overcome the armature reluctance, X_b = back A.T., θ = half the



interpolar angle, λ = angle of lead, then the difference of magnetic potential between the pole-tip and a point distant by angle a from line of symmetry is—

$$1{\cdot}257\left(\frac{X_g}{2}+\frac{X_a(\theta-a)}{2\theta}\right)$$

up to the angle of lead; and between this and the line of symmetry it is—

$$1{\cdot}257\left(\frac{X_g}{2}+\frac{X_a(\theta-a)}{2\theta}+\frac{X_b(\lambda-a)}{2\lambda}\right).$$

The following table and curves give the figures, worked out for an armature, 35·6 cm. diameter, 1·42 cm. air-gap, pole face 140°, $\lambda = 10°$, 232 conductors, and total armature current 160 amperes.

Angle from Line of Symmetry. $= a$.	Length of Path in cm.	Diff. of Poten- tial.	Col. 3. / Col. 2.	Deduct	Symm. Induc- tion.	Cross M.M.F.	Cross Induc- tion.	Leading Induction.	Trailing Induc- tion.
0°	14·42	8,100	560	560	0	5,180	359	− 359	359
2°	13	7,950	611	504	107	5,180	398	− 291	505
4°	11·5	7,800	678	448	230	5,180	450	− 220	680
6°	10	7,650	765	392	373	5,180	518	− 145	891
8°	8·6	7,500	872	336	536	5,180	602	− 66	1,138
10°	7·17	7,350	1,025	280	745	5,180	722	+ 23	1,467
12°	5·8	7,310	1,260	224	1,036	5,050	870	+ 166	1,906
14°	4·2	7,270	1,730	168	1,562	4,920	1,170	+ 392	2,732
16°	3	7,230	2,410	112	2,298	4,790	1,596	+ 702	3,894
18°	2·4	7,190	2,990	56	2,934	4,660	1,940	+ 994	4,874
20°	1·95	7,150	3,660	0	3,660	4,530	2,320	+ 1,340	5,980
22°	1·7	7,150	4,200		4,200	4,400	2,590	+ 1,610	6,790
24°	1·5	7,150	4,760		4,760	4,270	2,850	+ 1,910	7,610
26°	1·44	7,150	4,955		4,955	4,140	2,870	+ 2,085	7,825
28°	1·43	7,150	5,000		5,000	4,010	2,810	+ 2,190	7,810
30°	1·42	7,150	5,040		5,040	3,880	2,730	+ 2,310	7,770

The paper also gives a mathematical determination of the total number of lines forming the fringe which surrounds the polar faces. R. B. R.

1745. *Direct-Current Motors.* **P. Houel.** (Électricien, **19.** pp. 227–231, April 14, and 266–268, April 28, 1900.)—The motion of the armature of a direct-current motor is given by—

$$\frac{d\omega}{dt} = \frac{\Sigma MF}{\Sigma mr^2},$$

where $\frac{d\omega}{dt}$ is the angular acceleration, ΣMF is the sum of the moments of the couples acting on the armature, and Σmr^2 is the moment of inertia of the armature, say **M**.

Also—

$$\Sigma MF = \frac{2I\Phi}{\pi},$$

where I is the armature current, and Φ is the number of conductors multiplied by the total flux through the armature. The counter E.M.F $= 4\Phi N$ where N is the number of revolutions per second. This may be written—

$$e = 4\Phi N = \frac{2\Phi\omega}{\pi}.$$

If E is the applied potential difference we get—

$$\frac{d\omega}{dt} = \frac{2E\Phi - \pi\rho\Sigma MF}{\pi\rho M} - \frac{4\Phi^2\omega}{\pi\rho^2 M},$$

whence—

$$\omega = \frac{\pi}{2}\cdot\frac{E}{\Phi}\left(1 - \frac{1}{E}\cdot\frac{\pi\rho\Sigma MF}{2\Phi}\right)\left(1 - 1\Big/ e^{\frac{4\Phi^2}{\pi^2\rho M t}}\right).$$

As t increases this becomes—

$$\omega = \frac{\pi}{2}\cdot\frac{E}{\Phi}\left(1 - \frac{1}{E}\cdot\frac{\pi\rho\Sigma MF}{2\Phi}\right),$$

Or—

$$N = \frac{E}{4\Phi}\left(1 - \frac{1}{E} \cdot \frac{\pi\rho\Sigma MF}{2\Phi}\right).$$

When the angular velocity is steady this becomes—

$$N = \frac{E}{4\Phi}$$

The time taken to attain a steady velocity is given by—

$$t = 5{\cdot}685 \frac{\rho M}{\Phi^2} \log n$$

Where—

$$1 - 1 \Big/ e^{\frac{4\Phi^2}{\pi^2 \rho M t}} = \frac{n-1}{n}$$

W. G. R.

1746. *Slip-ring and Commutator Losses.* **G. Dettmar.** (Elektrotechn. Zeitschr. 21. pp. 429–436, May 31, 1900.)—The main object of this paper is to establish rules for the best sizes of brushes. The losses occurring with carbon brushes, which are gradually superseding copper ones, are considerably higher than when these latter are used. The subject of slip-rings is considered first. Curves are given showing the variation of the contact resistivity (*i.e.*, the resistance per square cm. of contact area) with peripheral speed for various currents, its variation with current for various speeds, and its variation with pressure for a given current, for both copper and carbon brushes. These curves clearly bring out the following points: (1) The change of contact resistivity with speed is dependent to an extraordinary degree on the material of which the brushes are made; in all cases there is a rapid initial increase of resistivity as the machine starts from rest; with copper gauze brushes the resistivity becomes practically constant beyond a speed of 1 metre per second. With brushes of sheet copper the resistivity reaches a maximum, and then decreases with further increase of speed; with brushes of sheet brass there is a steady increase of resistivity within all ordinary limits of speed; lastly, carbon brushes give results similar to those obtained with copper gauze brushes. (2) The contact resistivity always decreases with increasing current density, although the exact law connecting these two quantities depends on the material of the brushes. (3) The contact resistivity steadily decreases with increase of pressure. Since the electrical loss at the surface of contact decreases, while the friction loss increases, with increase of mechanical pressure, it follows that for a given current density there will be a certain value of the pressure which gives the least total loss. The author finds that under average conditions a pressure of 125 grammes per square cm. for copper gauze, and 140 grammes for carbon brushes, gives the best results. It is next shown that, assuming the above values of the pressure, it is best with copper gauze brushes to use as high a current density as possible, while in the case of carbon brushes the best area of contact is given by the formula—

$$S = \frac{I}{3{\cdot}79\sqrt{v}}$$

where S is the total surface of contact of the brush, in square cms.; I the current, and v the peripheral velocity, in metres per second.

The author next deals with commutators, where the presence of insulation between the segments introduces a complication. Curves are given similar to those described above for slip-rings. The curves show that, for both copper

and carbon brushes the contact resistivity steadily decreases with increase of current density, and that for a given pressure and given current density it becomes, after a rapid initial rise, practically independent of the speed beyond a value of 2 metres per second. This latter result is in direct opposition to those obtained by Arnold [see 1899, Abstract No. 1266], but the author has proved experimentally that if the commutator is even slightly out of truth, the resistivity passes through a maximum as the speed is increased. With copper brushes it is best to work with the highest permissible current density and the least permissible pressure; while in the case of carbon brushes, assuming a pressure of 149 grammes per square cm., the best contact area is given by—

$$S = \frac{I}{0{\cdot}9 + 0{\cdot}71v}$$

The last section of the paper deals with the rise of temperature. A. H.

1747. *Motor Control for Printing-Presses.* (Amer. Electn. 12. pp. 196–198, April, 1900.)—The Cutler-Hammer Manufacturing Company of Milwaukee have worked out a multiple-solenoid system for automatically controlling the speed of large rotary presses. The low speeds of the motor required when "making ready" are obtained by shunting the motor armatures by a resistance and putting both in series with another resistance. The shunting resistance is automatically controlled by solenoids operated by relays. A complete diagram of the somewhat complicated connections and a detailed account of the operation of the system is given. E. H. C.-H.

1748. *Rotary Converter.* **E. Wilson.** (Inst. Elect. Engin., Journ. 29. pp. 409–435, April, 1900.)—The paper contains an account of experiments carried out with two similar continuous-current machines fitted with slip-rings, one of the machines acting as a two-phase generator and supplying power to the other, which ran as a rotary converter, being loaded on the continuous-current side. By means of instantaneous contact-makers, curves of P.D., current, and E.M.F. were obtained. These are given in the paper. The mechanical phase displacement of the converter armature was studied by means of the device explained in Abstract No. 752 (1900). Armature reaction has the effect of producing periodic fluctuations in the P.D. on the continuous-current side. Speed fluctuations of the generator due to a joint in the belt were found to cause oscillations of the converter armature. The concluding section of the paper deals with the regulation of rotary converters. The method of regulation by means of a variable reactance interposed between the generator and converter is discussed, and is compared with the method of compounding the converter. A. H.

1749. *Inductive E.M.F. in Transformers.* **J. B. Whitehead, Jr.** (Elect. World and Engineer, 35. pp. 660–662, May 5, 1900.)—The author explains, by means of a vector diagram originally given by Steinmetz, the effect of magnetic leakage in causing a drop of P.D. under various conditions of load. He next proceeds to calculate approximately, from the dimensions and relative positions of the coils, the values of the leakage inductances, on the assumption that the thickness of the insulation may be neglected. This investigation leads to the result that if the primary and secondary are divided into the same number of parts, which are then placed alternately, the leakage E.M.F. decreases with increasing subdivisions, approximately as the square of the number of subdivisions of either coil. A. H.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

1750. *Long-distance Power Transmission.* **G. Forbes.** (Inst. Elect. Engin., Journ. 29. pp. 629–657; Discussion, pp. 658–677, May, 1900; and in the Electrician, June 1, 8, 15, and 22, 1900.)—The paper consists of two parts. Part I. contains brief descriptions of the power plants at Los Angelos, Snoqualmie Falls, Paderna, Rheinfelden, Genoa, and Niagara. Part II. deals with Lord Kelvin's law of economy, the use of boosters and synchronous motors for supplying the idle component of the current, the relative merits of different kinds of polyphase systems, overhead and underground conductors, and the use of aluminium. The author draws special attention to the Thury system of power transmission [Abstracts Nos. 874 (1898) and 1369 (1900)], and states that in many cases this would give better results than a polyphase system. In connection with Kelvin's law of economy the following points are of importance: (1) When using water-power which is unlimited compared with the demand, the price of a H.P. hour is to be taken as the price of *generating* it; if, on the other hand, the supply of power is limited and the demand unlimited, the price is to be taken as that of *selling* a H.P. hour. (2) If the copper is mortgaged, the interest to be allowed on its price is the interest paid on the mortgage, say 4 per cent.; but if the copper is paid for out of capital, the interest is that to be paid in dividends on the capital, say 15 per cent. Tables are given showing the weight of copper per H.P. and kw. delivered at the receiving end of a transmission line 100 miles long with 10,000 volts at generating end—(1) without boosters; (2) with boosters, when the line is divided into two, three, and four sections respectively. The effect of inductance in increasing the drop along the line is next considered, and a table is given, by means of which the magnitude of this effect may be determined for various distances apart of the conductors in the case of a single-phase transmission. In comparing polyphase systems the author gives preference to the two-phase system, mainly on account of the fact that the two circuits may be electrically disconnected, either always, or else during tests; this facilitates the localisation of faults and gives greater security of working. In connection with the use of aluminium conductors, the author mentions that the chief drawback to its use, especially overhead, is its liability to become rotten; this defect does not exist if the metal be pure and especially free frcm sodium. He suggests painting or varnishing aluminium conductors.

In the discussion **Ferranti** expressed the opinion that rotary converters would give place to motor-generators, and that polyphase systems would be superseded by the single-phase one. **G. L. Addenbrooke** pointed out that very good lighting work could be done with a three-phase power plant. **A. H. French** contributed a full description of the Thury plant at Genoa.

In a further discussion of the paper by correspondence in the columns of *The Electrician*, **Perry** drew attention to the fact that in the tables given in the paper, efficiencies below 50 per cent. are given, whereas any case in which the efficiency happens to fall below this limit may, without changing the conductor, be converted into another having an efficiency of over 50 per cent. by simply increasing the P.D. across the motor terminals. He also pointed out that the booster system, which had been patented by Elihu Thomson

many years ago, was of no practical value, and that it was better in every case to transmit without the intervention of boosters. In reply, **Forbes** stated that the booster system was of importance only in special cases of unlimited cheap power, long distance, and no excessive voltage. **A. M. Taylor** showed, by working out a number of results covering the range of practice and plotted in the form of curves, that even with water-power costing only £1 per H.P. year it would not be economical to work with an efficiency below 50 %. A. H.

1751. *Power Transmission at Duluth, Minnesota.* **F. W. Springer.** (Elect. World and Engineer, 35. pp. 545–547, April 14, 1900.)—*The St. Louis River* drains an area of 38,000 square miles composed of pine land, swamps, lakes, and some arable land. The rainfall is about 30 inches per annum, and there are two periods of low water, one from summer drought, and the other from the freezing-up of the small streams and swamps, many of which freeze solid. The minimum flow occurs in winter, when the power may be estimated at 15,000 H.P. at a head of 600 feet. Recently a St. Louis power development company has been formed, and it is proposed to cut a canal four miles in length and to lay 800 feet of pipe line to a power station in the bed of the stream. This will give 350 feet head, or about 10,000 H.P. at minimum flow.

The Black River scheme is similar to the above. A masonry dam 20 feet high is to be built, which will give a head of 55 feet and a flow of water of 6,000,000 cubic feet. The pipe line is to be 54 inches diameter, and will be buried to prevent freezing. Two direct connected polyphase 800 kw. generators are to be installed, together with five (one reserve) oil transformers for raising the pressure from 440 to 18,000 volts. The pole line will consist of 35-feet cedar poles, 8 inches diameter at the top and set 52 to the mile, with three pin cross arms and 24-inch spacing. The conductors will be No. 1 bare copper mounted on three part Locke insulators.

The interesting point about these schemes is that, although many propositions have been made and much money spent, the development of the power running to waste did not become practicable until the application of long-distance transmission by electricity. With the prospect of the immediate development of such powers it looks as though what had long been hoped for would come to pass—that is, the beginning of the manufacture of iron and steel at Duluth and Superior. It is estimated that it will not cost more than $55 per H.P. to distribute the power. E. K. S.

1752. *Balancers for Three-wire Systems.* **F. S. Hickok.** (West. Electn. 26. pp. 280–282, May 5, 1900. Paper read before the Chicago Electrical Association, April 20, 1900.)—After a brief introduction, the author shows the necessity of devices for equalising the pressures on both sides of a three-wire system, and describes several methods by which this may be accomplished. In addition to the usual methods, it is possible to use either a single battery on only one side of the system, or a small generator mechanically coupled to a large one, and taking the place of the battery mentioned above, or various arrangements of motor-generators. The author recommends the latter system, using compound-wound machines; when the load is out of balance, one machine runs as a differentially wound motor, the other as a compound wound generator, and by proper adjustment of the compounding it is possible to obtain automatic regulation within 1 per cent. under all conditions. The precautions required to ensure success are briefly discussed, and instances given of the application of the system in practice. A. H. A.

1753. *Electrical Equipment of Ships of War.* **C. E. Grove.** (Inst. Elect. Engin., Journ. 29. pp. 530–602; Discussion, pp. 602–626, May, 1900.)—The paper applies chiefly, but not solely, to British practice. Part I. deals with general equipment. The standard lighting pressure is 80 volts, and the dynamo speed about 300 r.p.m., but 500 r.p.m. has been introduced with forced lubrication. The output varies by steps of 100 amperes up to 600. The ironclad type of dynamos has been practically superseded by multipolar machines, which have but little stray field. The British standard switchboard, which is described, does not allow of working the dynamos in parallel; other boards are described which provide for this, and the system of distribution is explained, with a schedule of lamps. Lead-covered rubber-insulated conductors are used, all stranded cables being multiples of No. 20 S.W.G., with a current density of 1,000 amperes per square inch; the cables are cleated to teak battens or direct to bulkheads, &c. The author describes a simple device, consisting of a slab of rubber and iron plates, for watertight glands, as well as other methods. Distribution boards are used for the lighting circuits, on which all fuses are collected; double wire circuits are standard. Lamps are hooked on the ends of the actual leads, in special watertight fittings. The navigation and signal lanterns are described at some length, with the alarm devices to indicate failure, and methods of signalling for various purposes with Ardois and Scott lanterns. For searchlights, the Parsons parabolic mirror is used, with inclined and horizontal hand-fed lamps. A Siemens automatic projector is also described, and the method of signalling by flashes explained. Communication between different points is of a complex character, and not altogether satisfactory as yet. Electric bells are used in conjunction with speaking-tubes; and the Graham loud-speaking telephone is also employed, but for use in warfare some form of printing telegraph is suggested. Torpedo and gun-firing circuits are always single-wired; for the former, two batteries are used, and the connections are so arranged that they can be readily tested, and the operations of opening the sluice-valve and completing the preparations respectively signalled to the conning tower, at which point the firing-key is placed. For gun-firing the circuits are confined to the firing station. Electrical range-finders and telegraphs are briefly described, as well as engine-room telegraphs, tiller transmitters, and revolution indicators.

Part II. of the paper is concerned with machinery and power distribution. Diagrams are given showing the location of the auxiliary machines, comprising upwards of 100 sets in a typical battleship. Ordinary enclosed traction motors are the most suitable type to meet the excessively severe conditions obtaining on board ship. The losses incurred in the use of steam are considered in detail, with examples, and the conclusions arrived at by J. K. Robison [see 1900, Abstract No. 929] as to the comparative weight and economy of electrical and steam auxiliaries are disputed, the author stating that on a ship with a bunker capacity of 2,000 tons, 262 tons would be saved in 25 days by the substitution of electricity for steam. Electromotors are particularly suited for driving fans, which on a battleship require about 100 E.H.P. for the boiler and engine-rooms alone; for forced-draught air-pumps, about 200 E.H.P. would be necessary. The application of electric driving to steering gear is discussed; this would require a motor of 150 H.P. on a large ship. For the capstans, motors of about 50 to 100 H.P. would be used; in some British ships the forward capstan is driven by steam and the after capstan by electricity. These machines have to work under very arduous conditions. Motors of 50 E.H.P. are used for boat and coal

hoists, and about 5 H.P. for ash hoists. Six or eight fans, taking 5 E.H.P. each, were formerly used for general ventilation, but recently about twice as many smaller fans have been substituted. Electricity has been little used in the British Navy for working guns, but in the United States and other navies its use for this purpose has been highly successful. It is important that turrets should be well balanced about the axis of rotation. Ammunition hoists are commonly worked by electricity. Particulars and numerous illustrations of all the apparatus mentioned are given. Summing up, it is estimated that a total motor capacity of 1,885 E.H.P. would be required, with a maximum possible demand of 1,385 E.H.P.; the probable maximum demand would be 1,015 E.H.P. Lighting would call for 100 kw., including projectors. About 800 kw. installed would be sufficient for the generating plant; for this the author suggests three sets of 200 kw. each and four of 50 kw. each. The question of using polyphase currents is discussed, but direct current is preferred. The author considers also the advisability of raising the standard pressure, and prefers a two-wire 200-volt supply to the three-wire system at 160 volts between the outers (a footnote states that the British Admiralty has now authorised the use of 100-volt dynamos). Ring mains are advocated, to diminish risk of injury in battle. The author concludes by a further comparison of steam and electrical plant, estimating the net increase in weight with the latter to be 55 tons, with a saving of 262 tons of coal in 25 days' steaming.

The discussion consisted largely of criticism of the policy of the British Admiralty. Apart from this, **S. Evershed** gave additional information respecting his engine-room telegraphs; **R. E. Crompton** urged the advantages of horizontal carbons with automatic feed and short focus mirrors for search-lights, and the superiority of electrical motors over steam and hydraulic machinery; **A. E. Richards** gave a large amount of general information, dealing principally with experience gained in the British Navy, and including the results of actual trials of electric fans, hoists, and capstans; **H. Wilde** supplied interesting historical details; **F. L. Noakes** stated that open motors, not in exposed places, were more durable than the enclosed type. A. H. A.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

1754. *Dortmund Electricity Works.* **J. R. Dick.** (Electrician, 45. pp. 42–45, May 4, and 81–85, May 11, 1900.)—*System:* Continuous current in urban, and three-phase in suburban areas, both for lighting and power. The *boiler-room* contains water-tube boilers, 170 lbs. working pressure, with superheaters. Efficiency 70 per cent. when working at 140 lbs. and 27° F. superheating, burning good steam coal. The *engine-room* contains four 600 I.H.P. horizontal compound condensing engines running at 90 r.p.m. The steam consumption is 14·3 lbs. per H.P. hour when working at 500 I.H.P. Two of the engines drive directly 30-pole continuous-current twin dynamos with distinct armatures and common magnets. Each armature gives 200 kw. at 220 to 370 volts. Two armatures can be coupled in parallel for charging batteries or three-wire system, or in series for traction. The remaining two engines drive directly 400-kw. 2,600-volt three-phase generators, having a periodicity 50, excited from the continuous-current 'bus bars. The feeders are of steel armoured lead-covered single cables not exceeding 0·3 square inch area, at a potential difference of 200 volts with no middle wires. There are 13 feeders *radiating* from the first substation, 16 from the

second, and 9 from the third. The average section is 0·15 square inch. The distributors are of steel armoured lead-covered cables, with earthed middle wire of bare tinned copper, all having an equal section. The three-phase distributors are three-core lead-covered steel-armoured, laid directly in the ground. The voltage is 2,600 volts reduced to 120 volts by single transformers on consumer's premises. The three substations are each equipped with a Gottfried Hagen battery of 132 accumulators, having a capacity of 3,536, 1,768, and 1,768 ampere hours respectively; efficiency 80 per cent. in kw. hours. The price charged is 6d. per unit for lighting and 2½d. per unit for power, with discounts based partly on units sold and partly on load factor of kw. installed. *Drawings:* Scale plan of engine-room, diagrams of switchboard connections, load curves, and maps of mains. J. T. R.

1755. *Coventry Electricity Supply.* (Elect. Rev. 46. pp. 833–837, May 18, 1900.)—*System:* High tension alternating with grouped transformers. The *boiler-room* contains four Lancashire boilers each capable of evaporating 5,000 lbs. of water per hour. Two of these are 30 ft. × 7½ ft. and two 30 ft. × 8 ft. diameter. Induced draught is produced by a fan drawing the waste gases from the economiser and delivering into the chimney above the damper. The chimney is 100 ft. high by 5½ ft. sq. The feed-water is heated by a Green's Economiser. The coal is fired by Proctor mechanical stokers fitted to each boiler, driven by a small Tangye engine. The *engine-room* contains three horizontal low speed rope-driven generating sets of 50, 100, and 200 kw. respectively, and a direct coupled Belliss-Fynn set of 300 kw. The horizontal engines are compound by J. Fowler & Co. The Belliss engine is a three-crank compound running at 368 r.p.m. Each horizontal engine drives by means of ropes an alternator of the Hall type working at 2,000 volts, 87 periods, with revolving fields and stationary external armatures. The vertical engine is direct-coupled to a Fynn alternator of the inductor type, made by Easton, Anderson & Goolden under Mordey's patents. Its output is 150 amperes at 2,000 volts. The exciters, in the case of the rope-driven machines, are rope-driven from the alternator shafts, but that for the Belliss set is carried on the bedplate and driven by an extension of the shaft. The distribution of current is briefly as follows: the high tension mains are concentric paper-insulated lead-covered cables laid on the solid system; there are 9 substations, and 3 districts fed by transformers placed in boxes beneath the pavement. The current is transformed down and supplied to the low-tension network at 200 volts. The low-tension distributing mains, however, are not interconnected between substations, and can all be disconnected by switches in their respective substations. The equivalent of 17,806 8-c.p. lamps is connected. The price charged is 6d. for one hour and 3d. afterwards per unit for lighting, and 2d. per unit for power. The method of charging is the "Wright" system. E. H. C.-H.

1756. *Three-phase Transmission Plant at the Humboldt II. Coal-Mines, Brüx.* **A. Kolben.** (Zeitschr. Elektrotechn. Wien, 18. pp. 266–271, May 27, 1900.)—A description of a three-phase mining plant laid down by the Elektricitäts Actien Gesellschaft, formerly Kolben & Co., of Prague. The generators are belt-driven by two 170-H.P. horizontal engines running at 170 r.p.m.; they have 14 poles and give 2,150 volts at 50 cycles per sec. Particulars are given of the substation in which the voltage is reduced to 360, and of the various circuits and motors for ventilating, &c. E. K. S.

1757. *Polyphase Transmission at Montpelier (U.S.A.).* **J. L. Thomas.** (Elect. World and Engineer, 35. pp. 544–545, April 14, 1900.)—The plant now opened by the Consolidated Lighting Company, of Montpelier, is composed of a water-power generating station at Bolton Falls on the Winooski River, Waterbury; a steam plant and two step-down transformer houses in the city; and a step-down transformer house that is being erected at Barre, six miles from Montpelier, and twenty-three miles from Bolton Falls. The water-power plant consists of two 450 kw. General Electric three-phase, 60-cycle, generators, delivering current direct to the line at 11,000 volts. They are direct connected to horizontal turbines operating under a head of 50 feet. The seventeen miles of line between Bolton and Montpelier consists of three No. 4 bare copper wires supported on porcelain insulators on a 6 pin cross arm. Three more wires are to be added later for power work. The step-down transformers are 100 kw. of the air-blast type, 11,000 to 2,000 volts, and are provided with expulsion cutouts and oil switches. E. K. S.

1758. *Electrical Equipment of a Packing House.* **J. E. Smith.** (Amer. Electn. 12. pp. 201-208, May, 1900.)—At the great Armour meat-packing establishment in Chicago sixteen scattered steam engines were previously used, but these have now been replaced by a compact electrical generating plant supplying power to motors throughout the works. The boilers are of the Wickes vertical water-tube type, and each is rated at 375 H.P. They supply steam to three Corliss compound condensing engines, each of which is coupled direct to a 550-volt dynamo, supplying current for motors, and is also coupled by ropes to an 1100-volt alternator for incandescent lighting. The motors range from 1½ to 200 H.P., and number altogether 111, aggregating 3,600 H.P. In most cases one motor is used for each floor, single reduction toothed gearing being generally employed between motor and shafting. Compressed air motors are installed in the cold-storage rooms. W. H. E.

1759. *Electrical Equipment of the Chicago Great Western Railway Shops.* (Amer. Electn. 12. pp. 177–178, April, 1900.)—The generating plant consists of three 100-kw. Crocker-Wheeler machines, driven by two tandem compound Ideal engines. Engines and generators are coupled by magnetic clutches and run at 250 r.p.m. One engine has sufficient capacity to drive two of the generators, the other is half the size; but the smaller engine is provided with an auxiliary steam connection by which high-pressure steam may be admitted to the low-pressure cylinder, thus furnishing means by which the engine may be run on 100 per cent. overload: the mechanical parts of this engine are designed with this in view. Three Stirling boilers are installed under a guarantee to evaporate into steam containing not more than 3 per cent. moisture, from and at 212°, eight pounds of water per lb. of coal burned with a draught of 0·6 inch at the base of the stack; the calorific value of the coal being taken as 11,500 B.T.U. per pound. The exhaust steam is passed through oil extractors and used to heat the building.

Current for both motors and lamps is supplied at 220 volts; there are six hundred 16-c.p. incandescent lamps and fifty-one 1,200-c.p. arc lamps used. All tools and machinery are driven by electric motors, except some pneumatic tools in the boiler and erecting shops, and the air lifts. The contract requires that all motors shall deliver their rated output for 18 hours per day, with an average efficiency for all sizes of not less than 88 per cent. at full load, 86 per cent. at three-quarters load, and 83 per cent. at half load; to be capable of carrying 25 per cent. overload for two hours with safety, and in starting to be able to

develop 50 per cent. more than their rated output. Thirty motors, varying in size from 2 H.P. to 60 H.P., are used in the shops. All are Crocker-Wheeler machines except a G.E.-52 motor for the transfer table and the motors on the machine shop crane. The transfer table takes current from two overhead wires, and is capable of carrying the largest coach and the heaviest locomotive used in railway practice. The tools of the machine shop are driven by belts from two lines of shafting each 75 feet long and each driven by a 20-H.P. motor. The two shafts can be coupled together by an Arnold magnetic clutch, so that one motor may be used to drive the two. The boiler-shop tools are driven by one 20-H.P. motor in a similar manner. The bulk of the power is used in the wood mill, where there are five shafts each driven by a motor. The blacksmiths' shop is equipped with down-draught forges, with Sturtevant fans driven by a 25-H.P. motor, also a small steam hammer, a punch and shear, and a forging machine, driven by a 10-H.P. motor. In the yard the turntable, the coal-shoot, and other labour-saving apparatus are also to be equipped for electric power.

The article is illustrated by two views of the generating plant and a vertical cross-section showing the arrangement of the power house. E. D. P.

1760. *The Waterloo and City Railway.* **H. H. Dalrymple-Hay.** (Inst. Civ. Engin., Proc. 139. pp. 25–55, March, 1900.)—Previous schemes were abandoned owing to cost of property required for the construction of an ordinary line with a City terminus. A junction with the South-Western line was impossible owing to the great difference in levels, the rails being 41 ft. below those of the South-Western Railway. At the City terminus the rails are 59 ft. below the surface of Queen Victoria Street. In the construction of the works a stage with shafts in the river formed the base of operations. The direction of the work below ground was tested through check borings in three places by means of fine piano wire and plumb-bobs. The errors in direction were very small. Measurements were made underground by ½ in. or ¾ in. steel tapes and corrected to the horizontal by levelling and calculation. Two temporary shafts, 16 ft. internal diameter and 45 ft. long, of cast iron, were sunk from the timber stage just above Blackfriars Bridge over the line of each tunnel, through which the excavated material was raised in skips by cranes and barged away. The two tunnels, one for up and the other for down trains, were driven by means of four Greathead shields and lined with cylindrical cast-iron lining 12 ft. 1¾ in. diameter inside the flanges on the straight or curves of not less than 9 chains radius, and 12 ft. 9 in. on those of 5 chains radius. Red rubber or yarn was used for making the joints in water-bearing strata, and rust joints elsewhere. The Greathead shield was used exclusively for tunnelling in clay. It consisted of an iron cylinder 13 ft. 2 in. diameter, 7 ft. long, armed with a cutting edge of slightly less diameter, at its forward end, which was provided with a diaphragm of iron plate having an opening 6 ft. 6 in. by 5 ft. 6 in. through which the excavated material from the front of the shield was removed. The shield was pushed forward by 7 hydraulic rams attached to the shield, the heads taking a bearing on the flanges of the cast-iron tunnel lining which was built within the tail of the shield so as to follow it up. The space between the excavation and the cast iron lining was filled with a lime grout. In order to assist excavation short piles were pushed forward by the shield and detached lumps of clay which were removed by miners from the front of the shield and afterwards by skips through the temporary shafts to barges. The rate of tunnelling was about six complete 20 in. rings of cast-iron liners, or 10 ft. per day of twenty-four hours. In

water-bearing strata tunnelling was more difficult. Compressed air at about 12 lbs. pressure per square inch was employed to prevent the water from leaving the ballast and so causing a settlement overhead. The excavation in the front of the shield had to be timbered to prevent the roof and "face" from falling in before the shield could be pushed forward. In some cases the roof timbering was built in, but where decay was probable it was removed. A modified or "hooded" shield, 9 ft. 6 in. long, having more powerful rams and a long cutting edge, which could be pushed forward into the ballast before excavating, was subsequently employed. The shield for the 23-ft. tunnels is described, as are also the works at Waterloo and the City, the lifts, and the system of drainage.

The paper is illustrated by three plates giving a map, gradients and levels of the route, and illustrations of the shields and some of the works. A discussion followed the next paper on "The Electrical Equipment of the Waterloo and City Railway" [see following Abstract]. J. T. R.

1761. *Electrical Equipment of the Waterloo and City Railway.* **B. M. Jenkin.** (Inst. Civ. Engin., Proc. 139. pp. 56–96; Discussion, pp. 97–176, March, 1900.)—The trains are worked by electrical energy from the power station at the Waterloo end of the line. The power house, consisting of boiler house, engine-room, workshops, and offices, contains five Davey Paxman boilers, 14 ft. long, 8 ft. diameter, each with two flues 2 ft. 8 in. diameter, and 92 tubes of 3 in. internal diameter. Heating surface 1,180 sq. ft., grate surface 18·5 sq. ft., working pressure 160 lbs. per sq. in. The boilers are fitted with Vicar's mechanical stokers. The 140-ft. chimney has an area of 43 sq. ft., and gives a draught of between $\frac{1}{2}$ in. and $\frac{3}{4}$ in. of water, with four boilers working. The feed-water is heated by a Green Economiser in two parts, having together 480 tubes, 4 in. diameter. The engine-room contains six three-crank, vertical, double-acting Bellis engines, each indicating 360 H.P. at 385 r.p.m. Each drives directly a Siemens two-pole drum dynamo, compounded to give 500 volts at no load, and 530 volts at full load. The flywheels weigh 6 tons. Condensation is by an evaporative condenser above the feed tank outside the boiler house. Coal is brought by the London and South-Western Railway, and lowered in trucks by the main carriage lift, thence by electric locomotive to a 20-ton hydraulic lift, by which it is lifted 17 ft. to a siding outside the boiler house. Below is a coal store into which the trucks are emptied. The Westinghouse brake reservoirs on the trains are charged by air pumps through a storage reservoir at 100 lbs. pressure. The tunnels and stations are lit by the equivalent of 1,848 8-c.p. lamps, generally 5 in series on the 500-volt circuit. Two main feeders, each $\frac{3}{4}$ sq. in. section, consisting of two cables in parallel are carried to link boxes in Waterloo station, and branches are carried through links to the different sections of conductor rail in the main line and sidings. From Waterloo a single lead-sheathed jute insulated cable, 0·5 sq. in. sectional area, is run down each tunnel and forms the feeder for that tunnel. The conductor rail, consisting of a steel channel 4 in. by 2 in., with 4·5 sq. in. section, is carried on porcelain oil-insulators attached to the permanent way transomes, and is divided into nine sections which can be disconnected from the feeder. The resistance of the conductor rail with bonds and connections was found to be 0·051 ohm per 1,000 yards. The permanent way is of standard South-Western pattern, having bull-headed rails weighing 87 lbs. per yard. The rails and conductor rail are bonded by copper bars, 2 in. by $\frac{1}{2}$ in. in section, hydraulically riveted to the rails at each end by three $\frac{3}{4}$ rivets. The running rails are cross bonded every 100 ft. by

0·125 sq. in. cable, and the rails in the separate tunnels are connected at each of the ten connecting passages. A return copper conductor 1 sq. in. section is connected every 100 ft. between each pair of rails for a distance of 3,300 ft. from Waterloo. A train consisting of four carriages, each carried by two four-wheeled bogies, will carry 204 passengers. One bogie of each of the two end carriages carries two 60-B.H.P. motors driving the axles directly without gearing. There is a clearance of 5 in. between the tops of the carriages and the tunnel. On each motor carriage two collecting-shoes make contact by rubbing on the conductor rail. The controllers have eight working positions, and place all four motors in series or parallel.

The following are the results of a whole day's test during running hours :—

1.	Date of test	December 29, 1898
2.	Duration of test, 7 a.m. to 10.35 p.m.	15 hrs. 35 mins.
3.	Total coal burnt	18,600 lbs.
4.	„ water evaporated	169,000 lbs.
5.	„ units generated	2,160 kilowatt-hours
6.	„ „ taken by lighting and pumps	730 „ „
7.	„ „ „ for working trains	1,430 „ „
8.	Number of journeys run (Up and Down counted as one journey)	112
9.	Number of passengers carried (estimated)	12,000
10.	Total train-miles run	325
11.	Average weight per train, including passengers (estimated)	93 tons
12.	Total ton-miles run	30,225
13.	Water evaporated per lb. of coal, actual	9·09 lbs.
14.	„ „ „ „ from and at 212° F.	9·72 lbs.
15.	Coal per unit generated	8·6 lbs.
16.	Calorific value of coal	12,140 B.T.U.
17.	Coal per train-mile (excluding pumping and lighting)	37·8 lbs.
18.	Coal per ton-mile (excluding pumping and lighting)	0·407 lbs.
19.	Water per unit generated	78·2 lbs.
20.	Units per train-mile	4·4 kilowatt-hours
21.	„ „ ton-mile	0.047 „ „
22.	Average units per Up journey	5·26 „ „
23.	„ „ „ Down journey	6·36 „ „
24.	„ „ „ journey for shunting at Waterloo	1·15 „ „
25.	Load factor	33·5 per cent.
26.	Maximum observed momentary load at power house	330 kilowatts
27.	Maximum load averaged over 6 minutes	201 „
28.	Mean volts at generating station	505 volts
29.	Maximum observed drop in pressure on return circuit from City to Waterloo	4·4 volts
30.	Mean observed drop in pressure on return circuit from City to Waterloo	1·62 „

In the Discussion **G. Forbes** pointed out that probably the reason for having motors at each end of the train was the difficulty of transferring a single motor car from one end of the train to the other at the termini. Half the power was pulling and half pushing, which, though not seriously dangerous, was probably the reason why the Board of Trade objected to the intended speed (24 miles per hour) round sharp curves. The diminished speed (15 miles per hour) at which the trains were allowed to run had made a difference to the general speed. **Carus-Wilson** drew attention to the gain by using roller bearings, the average resistance being 6 lbs. or 7 lbs. per ton instead of 13 lbs. per ton given by McMahon for the City and South London Railway. **W. R. Galbraith** referred to the restrictive clauses in Electrical Railway Acts which had been unfairly introduced. He thought it would have been better had the Central London Railway tunnels been 12 ft. diameter, and the station tunnels 23 ft. diameter as for the Waterloo and City line, than 11 ft. 6 in. and 21 ft. respectively. He strongly recommended the hooded shield propounded by Hay where there was danger of settlement. **G. F. Deacon** thought that tunnels should be well below the suface of the London clay to prevent disturbance of the surface; that access should be by numerous hydraulic lifts; and that grouting pressure should be continuously maintained quite up to the shield, while the cutting edge should always penetrate the face of clay. **E. W. Moir** advocated the Sprague multiple-unit system, and pointed out the advantage of rapid acceleration thereby obtained in keeping up the average speed. **A. B. W. Kennedy** mentioned the inequality of the load due to a six-minutes train service. He did not think other engines were better than high-speed engines for electric traction. **E. Thomas** called attention to the advantages of cut-off governing, by which the average load could be made the most economical. **H. H. Dalrymple-Hay,** in reply, said that the rate of tunnelling depended on the time required for the grout to set. **B. M. Jenkin,** in reply, said that the compounding of the dynamos was a disadvantage to the lighting: the variations in load were so rapid that the machines could not follow them. The volts lagged behind, the current making the pressure more unsteady than when working with shunt machines. He agreed that expansion-governing compared to throttle-governing made it possible to overload an engine to a much greater extent.

There are six plates illustrating the shields, tunnels, generating station, rolling stock, motors, &c. J. T. R.

REFERENCES.

1762. *Arc Lamps.* **G. Richard.** (Écl. Électr. 23. pp. 161–168, May 5, 1900.)—An article dealing with recent patent specifications, and containing the various patent drawings. The lamps described are the Wood, Prentis, Warner, Chagnaud, Woltmann, Mozer, Davy and Upton lamps. [See also Abstracts Nos. 958 (1899), and 777 (1900).]

1763. *Berlin Metropolitan Railway.* (Tram. Rly. World, 9. pp. 217–226, June, 1900. Translated from the Elektrotechn. Zeitschrift.)—Article giving particulars of the scheme proposed by the Union Elektricitäts-Gesellschaft for the employment of electric traction.

TELEGRAPHY AND TELEPHONY.

1764. *Wireless Telegraphy with Free Balloons.* **J. Vallot,** and **J.** and **L. Lecarme.** (Comptes Rendus, 130. pp. 1305–1307, May 14, 1900.)—It was proved (1) that an earthed wire is not indispensable for a long-distance transmission, and (2) that signals were clear even though the two vertical antennæ were vertically above one another. M. O'G.

1765. *London Telephone System.* (Elect. Rev. 46 pp. 774–775, May 11, and 815–816, May 18, 1900.)—This is a description of the proposed Post Office system. The area extends from Reigate northwards to Waltham Abbey, and from Romford westward to Harrow, and embraces about 600 square miles. Work will be commenced in the Embankment, Westminster, and Kensington sub-areas, to be followed immediately by the City work and the suburbs later. The Central Exchange will be in the Savings Bank building, Queen Victoria Street. Exchanges at Westminster, Kensington, Wimbledon, Putney, Richmond, Chiswick, Kingston, and Twickenham will be opened almost simultaneously. The cables to be employed are paper-insulated and lead-sheathed. For subscribers' lines the conductors will weigh 20 lbs. per mile, the mean diameter being 35·5 mils. and the maximum resistance 43·89 ohms per mile. The junction lines will weigh 40 lbs. per mile, have a mean diameter of 50 mils., and a maximum resistance of 21·94 ohms per mile. The largest cables will be for subscribers' lines, 217 pairs; for junction lines, 108 pairs. Tables give sizes of cables and particulars of number of pairs, mean thickness of lead, maximum external diameter, average weight per mile, also number of pairs in each layer of stranded cable. The mean wire-to-earth capacity of each wire is 0·08 mf. per mile. The mean wire-to-wire capacity of each pair must not exceed 70 per cent. of the mean wire-to-earth capacity. The insulation resistance is 10,000 megohms.

The ducts to be used for the conduits will be of glazed earthenware. In some cases fifty of these ducts will be used in one trench. The section of conduit is illustrated. The ducts will be built in cement according to a method which is described and illustrated. Jointing chambers—or manholes—will be of two classes, one for roadway, another for footway, and they will vary according to the number of cables to be brought in. Dimensions of three standard sizes are given, and the construction is described.

The switchboards for the Central Exchange will be fitted to accommodate 10,000 subscribers, Westminster and Kensington Exchanges for 2,000 subscribers, "outer" sub-exchanges for 600 subscribers, with provision for subsequent additions.

The system of working will be the "central battery system" in the City and the inner sub-exchanges. The action of lifting the receiver causes a lamp to light and the attention of the operator is gained automatically. Other features of the working of the central battery system are briefly referred to.

The rates to be charged for service are not yet published, but they will probably be on the "toll" rate system. J. E. K.

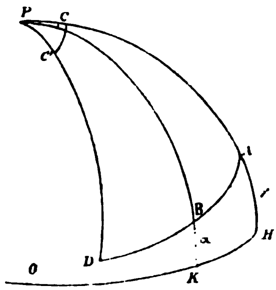
SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

SEPTEMBER 1900.

GENERAL PHYSICS.

1766. *Angular Measurement by Mirrors.* **A. Schuster.** (Phys. Zeitschr. 1. pp. 225–227, Feb. 17, 1900.)—In the optical measurement of angles it is assumed that the mirror is parallel to its axis of rotation. This cannot always be ensured, and it may happen that in a vertical suspension the mirror is inclined a degree or so to the vertical. Let O (see diagram) be the centre of the mirror, OP the axis of rotation, and OA the direction of the incident ray. If the normal to the mirror is originally in the plane OPA, and the mirror is deflected until its normal lies in OB, APB is the angle to be measured. Let



it be denoted by C. The reflected beam will lie in the plane OAB such that AB = BD. The angle APD (C') is directly read from the scale, and we must now have an equation connecting C and C'. Let γ be the inclination of the incident beam, and a that of the mirror normal. Then since BD = AB = C, we have sin 2C sin A = sin PD sin C', and eventually

$$\frac{2\sin(C'-C)}{\sin C'} = \frac{\cos\gamma}{\cos C\cos^2 a\cos\gamma + \sin a\cos a\sin\gamma}$$

in the most general form. For practical corrections the author gives the equation

$$dx = xa(\gamma - a)$$

to be added to the scale reading x. E. E. F.

1767. *New Curve-tracer.* **M. Dechevrens.** (Comptes Rendus, 130. pp. 1616–1620, June 11, 1900.)—This machine, which the author terms the campylograph, is an extension of the instruments constructed for the drawing of Lissajou's figures. Some of its features resemble those of the machine shown in 1889 by Rohn, but the two slotted rulers can be made to move quite independently of each other, with a large variety of velocity ratios. In addition, the support of the paper can be given a movement of rotation, which is then superimposed upon the ordinary figures. The author reproduces a variety of beautiful patterns. The instrument can also describe ellipses and parabolas. E. E. F.

1768. *Apparatus to measure Extension of Wires.* **G. F. C. Searle.** (Cambridge Phil. Soc., Proc. 10. pp. 318–323, May 7, 1900.)—Two similar wires side by side have at their ends small rectangular brass frames, 11 cms. long, the loads being placed below the frames. A sensitive level is placed between the two frames, resting at one end on a micrometer screw, which gives the lengthening of the wire stretched, and may be read to $\frac{1}{1000}$th mm. The apparatus has been used in the Cavendish Laboratory to investigate the deviations from Hooke's law for copper wire, well-marked hysteresis curves being obtained. It is shown, using G. A. Shakespear's results, that the error introduced by assuming that the coefficients of expansion of the two wires are identical under different stresses is quite negligible. G. E. A.

1769. *Method of Testing Weights.* **T. W. Richards.** (Zeitschr. Phys. Chem. 33. pp. 605–610, June 1, 1900).—The author describes a simple method of determining the corrections of weights which is based upon weighing by substitution. This has the advantage of eliminating a possible inequality in the arms of the balance, and avoiding the errors usually attending the change of weights from one arm to the other. The comparison begins with the centigramme weights, one of which is balanced by a counterpoise, after which the next centigramme weight is put on and the balance re-established by means of the rider. The weights are thus compared in succession, the gramme being balanced against all the centigrammes, and so forth. This gives a number of equations equal to the number of weights, less one. It is most convenient to suppose that one of the centigramme weights is correct, and to calculate all the others in terms of that. The result is that the larger weights have a disproportionately large correction, but that may be avoided by subsequently taking one of them as a standard and reducing the others to it, and the author gives an expedient by which this recalculation may be simplified. E. E. F.

1770. *Specific Gravity of Yttrium, Zirconium, and Erbium.* **S. Meyer.** (Akad. Wiss. Wien., S.ber. 108. pp. 767–770, 1899).—The element yttrium, which has been previously shown by the author to be paramagnetic, occurs in the periodic system among a series of diamagnetic elements. To ascertain whether it is situated in its proper position, the author determines the specific gravity of the three metals, yttrium, zirconium, and erbium, using a volumenometer specially adapted for use with powdered materials. The numbers found are: yttrium, 3·80; zirconium, 4·08; erbium, 4·77; the corresponding atomic volumes are hence 23·6, 22·6, and 34·9 respectively. The value for yttrium is hence in perfect accord with its position in the periodic system, and its abnormal magnetic behaviour must be ascribed to its admixture with some known or unknown element having an atomic weight lying between 140 and 180. T. H. P.

1771. *Density of Gases.* **R. Jahoda.** (Akad. Wiss. Wien., S.ber. 108. pp. 808–810, 1899.)—This paper describes some experiments on the comparison of densities of gases by the organ-pipe method. The pipes used were closed ones, one having a movable piston. The position of this piston for equality of frequency when the pipes are blown, one with air and the other with the gas, is a measure of the relative densities. A scale is fitted, and can be calibrated in densities. The following results are given :—

CO_2 1·521, Coal Gas 0·490, Water Gas 0·631, Oxygen 1·118.

The author has also used the method to determine the percentage of CO_2 in a mixture of gases. J. B. H.

1772. *Dust Nuclei.* **C. Barus.** (Science, 11. pp. 201–206, Feb. 9, 1900. Prelimin. Rep. of Work under Grant from Smithsonian Inst.)—Observations on the condensation of supersaturated steam obtained from jets, following the general method of colour tubes (U.S. Weather Bureau, Bull. No. 12, pp. 104, 1895). It is already clear that the velocity of diffusion of dust particles ejected from phosphorus by an oxygen reaction is independent of their density of distribution. The author still thinks condensation is always primarily due to nuclei, and that whether they are ionised or not is of secondary, perhaps negligible, consequence. The fine phosphoric dust travels with a definite velocity, is absorbed by surface, and liberated by heat; but it does not appear to be ionised. There is no noteworthy difference between the action of air carrying such dust and that of ionised air. On the other hand air bearing phosphoric dust will dissipate charges, as if the phosphorus when emitting dust emitted at the same time some form of obscure radiation. Sulphuric acid does not produce this effect. There is promise of a non-electric, purely optical method of measuring the individual velocity, and possibly the mass of the dust particles absolutely. A. D.

1773. *Viscosity of Sulphur at Temperatures above that of Maximum Viscosity.* **C. Malus.** (Comptes Rendus, 130. pp. 1708–1710, June 18, 1900.) Experiments made according to Gernez' method. Let

S_1 = sulphur which has been kept for 10 min. at 357° C.
S_2 = „ „ „ „ more than 3 hrs. at 357° C.
τ' = time spent in a state of superfusion (cooling bath).
Δ = time required for the solidification of a column of supercooled liquid sulphur one centimetre long.

The results of eighteen different experiments are summed up as follows: "The Δ of S_1 at 100° depends on the velocity and temperature of cooling. It decreases when τ' increases, and tends towards the value $5\frac{1}{4}$ secs., which it attains after five or six hours, and which it preserves indefinitely; S_1, at first viscous, has then become quite fluid. This limiting value of Δ is the value of the Δ of S_2 at 100° from the very beginning. S_2 is fluid from the start, and its Δ is independent of the velocity of cooling, the temperature of the cold bath, and the length of its sojourn therein (τ')."

Further experiments lead to the following conclusion: "Sulphur, when kept for a long time at 100°, loses its viscosity just as at 360° C, but the cause which operates in restoring the viscosity persists in the sulphur which has lost its viscosity at 100°, although *it has* disappeared from the sulphur which has lost its viscosity *at 357°.*" F. G.

1774. *Diffusion (Transpiration) of Air through Water, and a Method of Barometry.* **C. Barus.** (Amer. Journ. Sci. 9. pp. 397–400, June, 1900).—The author proposes to study the rate at which a small volume of air escapes by diffusion through an enclosing wall of water. For this purpose he uses a small Cartesian diver. The paper is occupied with an account of a highly ingenious method for ascertaining the volume of air enclosed in the diver. Incidentally the author shows that the arrangement amounts to a water barometer of very short length. For the theory of this instrument reference must be made to the original paper. F. G. D.

1775. *Surface Tension and Viscosity of Liquid Air.* **C. Forsch.** (Phys. Zeitschr. 1. p. 177, Jan. 13, 1900.)—These are a few preliminary measurements intended for orientation only. The surface tension was measured by the method of capillary elevation, the capillary glass tube being immersed in liquid air under ordinary pressure. The surface tension came out at about 1·23 mg. per mm. Much of the nitrogen had already evaporated when the measurements were begun. The viscosity was measured by the method of efflux through capillary tubes. The coefficient of viscosity was found to be 0·0033 c.g.s. units at the boiling point of liquid air under ordinary pressure.
E. E. F.

1776. *Superficial Tension.* **P. Dutoit** and **L. Friederich.** (Archives des Sciences, 9. pp. 105–132, Feb., 1900. Paper presented to University of Geneva, Jan., 1898.)—Ramsay and Shields' formula is that where a liquid rises to height h in a tube of radius r, d and a being the orthobasic densities of the liquid and of its saturated vapour, then its superficial tension in dynes per sq. cm. is $\frac{1}{2}rgh(d-a)=\gamma$; and then if M be the molecular weight of the liquid, and v its specific volume at temperature t, its superficial molecular energy is $\gamma(\mathrm{M}v)^{2/3}=k(t_c-t-d)$ where t_c is the critical temperature, d is a constant in value about 6, and k is about 2·12. The author finds a large number of cases in which k differs materially from 2·12. It rises as we ascend homologous series, as if the lower members of the series were feebly polymerised. It also varies with atomic groupings in the molecule. Ramsay and Shields' formula yields the following expression for the critical pressure. Taking the temperature such that $(t-d)=nt_c$, the formula becomes $\gamma(\mathrm{M}v)^{2/3}=t_c.k(t-n)$. Then we have approximately $\mathrm{M}v_c p_c=\mathrm{A}t_c$; whence $p_c=\gamma\sqrt[3]{\mathrm{M}v}\,\mathrm{A}.\mathrm{M}v/\mathrm{M}v_c.\{k(t-n)\}^{-1}$, which, since $\mathrm{M}v/\mathrm{M}v_c$ is constant if we adhere to corresponding volumes, is of the form $p_c=\mathrm{Q}.\gamma\sqrt[3]{\mathrm{M}v}$. This enables critical pressures to be calculated within about one atmosphere. This expression is of the same order of exactness as Ramsay and Shields', from which it is derived. [See also Abstract No. 989 (1900)]. A. D.

1777. *Thickness of Transition Superficial Layers.* **G. Vincent.** (Journ. de Physique, 9. pp. 78–91, Feb., 1900; and Soc. Franç. Phys., Bull. 142. p. 5, Jan. 19, 1900. See also Annal. Chim. Phys. 19. pp. 421–432, March, and pp. 433–516, April, 1900.)—Superficial films, at the bounding surfaces of solids or liquids, might or might not appear to have different thicknesses according to the physical properties by means of which we explore them. Experiments of Reinold and Rücker and Quincke are summarised. The author finds that films of silver upon glass, if the thickness exceed 50×10^{-7} cm., are composed of a homogeneous layer of constant specific conductivity, and two superficial layers of constant thickness, whose conductivity is smaller but

fixed; and that the joint thickness of these two superficial layers is about 50×10^{-7} cm. Quincke's results are in agreement with this, and show that the action between the silver and water becomes constant as soon as these superficial layers are completely formed, and that the core takes no part in this action, nor yet the superficial layer on the glassward side. It is not necessary to conclude that the thickness of the superficial layer is equal to the radius of molecular activity: the latter might be, say, one-half the former; but it cannot exceed it. All the methods of experiment give data of the same order for the thickness of the transition superficial layers, about 25×10^{-7} cm. for each surface. A. D.

1778. *Transition Layers and Molecular Action.* **G. Quincke.** (Ann. d. Physik, 2.2. pp. 414–420, June, 1900.)—The author combats the idea put forward by G. Vincent that a thin silver surface is bounded on both sides by "transition layers" of a different constitution from the rest of the metal. He attributes the variation of the specific resistance to a variation of the density, and adheres to his opinion that the radius of molecular action is about 50 mm. Liquids are in many ways unsatisfactory for use in determining molecular forces. In soap bubbles and solutions generally, the constitution of the liquid film is not uniform. In soap bubbles the soap goes to the surfaces and the water remains in the central layer, so that one really has to do with three layers. In liquid layers of diameter less than twice the radius of molecular action, the change of density at the surface depends upon the time during which expansion takes place and the time during which the molecular forces of adhesion act upon the liquid particles. The changes of density involve other physical and chemical changes as well, and these also change with the time. Wedges of solid material are therefore preferable in all such determinations. E. E. F.

1779. *Anemometer Tests.* **C. F. Marvin.** (Monthly Weather Rev. 28. pp. 58–63, Feb., 1900.)—When testing anemometers in 1888 against a very large whirling machine with a radial arm 35 feet in length, placed in a closed court, the author obtained concordant results, but the same anemometers differed when compared in open air. The reason is that every natural wind is gusty, and a steady and a gusty air current affect an anemometer in a different manner on account of the inertia. In May, 1899, he installed a new whirling machine at Arlington, Va., in the open air. The radial arm, bearing the anemometer under test at its extremity, had a length of 28 feet, and the natural wind velocity was determined with the aid, first of an axial anemometer, and then by an anemometer fixed on an independent pole close to the apparatus. The machine was turned by hand or steam, the maximum circumferential speed being 60 miles an hour. It might be thought that a natural wind would neither accelerate nor retard the movements of the best anemometer with this arrangement. It is demonstrated, however, that there is always a gain in speed. The recording instruments comprised a battery, a seconds pendulum, an Alvan Clark astronomical chronograph with two pen carriages, and a telegraphic sounder to give audible signals that everything was in order. The five anemometers tested were a set of aluminium cups, 4 inches in diameter, 9·5 ozs. in weight; two small kite anemometers, 1·22 inches in diameter, weighing about 0·3 ozs.; and two sets of paper cups, about 4 inches in diameter, and weighing 1·3 and 1·7 ozs.; the length of arm to cup centre was 6·6 inches, and in one case 2 in. The resulting anemometer

speeds are slightly lower than those formerly obtained, and on the whole the open air tests confirm the previous experiments. Tilting the anemometer axis did not seem to have much effect; but the apparatus was not suited for such experiments. H. B.

1780. *Cloud Observation in U.S.A.* **F. H. Bigelow.** (Monthly Weather Rev. 28. pp. 8–12, Jan., 1900; from the Amer. Journ. Sci. Dec., 1899.)—Observations were made by the U.S. Weather Bureau from May, 1896, to June, 1897, in the primary base station at Washington and at fourteen nephoscope stations distributed uniformly east of the Rocky Mountains. The 6,600 single theodolite and 25,000 nephoscope observations have been utilised to establish a standard system of constants and formulæ, and to compile new tables concerning cloud strata up to elevations of 15,000 m. and temperatures varying, for the several strata, between $-60°$ and $+40°$ C. For the reduction of the barometric pressure B to the sea-level value B_0, the usually employed formula $B_0 - B = B(10^m - 1)$, in which m is a function of temperature, humidity, gravity, altitude, and surface topography, is less convenient than $\log B_0 = \log B + m - \beta m - \gamma m$, where β refers to humidity and γ to gravity. In cloud formation we have to distinguish between the saturated, unsaturated, freezing, and frozen stages; and further, as regards the ratio of vapour pressure e to barometric pressure B, between true adiabatic saturation e/B and actual e_1/B_1. The kite ascensions of 1898 permit of doing this. The paper discusses briefly the problem, how much heat should be added to an ideal adiabatic atmosphere to produce the actual atmosphere in its several layers, and the motions of the atmosphere with special regard to cyclones which are formed in large numbers on the North-American continent and dissipate in Europe and Asia. The author questions the ordinary canal circulation theory, which assumes a southward movement from the poles in the lower strata with a reversal of the component from east to west at lat. 35°, and an overflow northward on the higher strata. In each stratum about as much air moves north as south, for there are enormous counter currents passing by each other at the same level, and not over one another at different elevations. The solar energy is absorbed chiefly in the lower strata, and a continuous leakage is developed in the lower strata, which is observed as our persistent winds from the south. This escape from the tropical belt diminishes the pressure in low latitudes which would require to be balanced by an excessively rapid eastward drift. The formation of cyclonic vortices discharging into the eastward drift and distorting it also retards the eastward velocity. H. B.

1781. *Polarisation of Corona, May 28, 1900.* **P. Joubin.** (Comptes Rendus, 130. pp. 1597–1599, June 11, 1900.)—The author, observing at Elche, on the east coast of Spain, used a telescope with terrestrial ocular, in conjunction with (1) a biquartz, (2) a *single wave* plate, and a nicol placed between the components of the ocular. No effect was noticed from the solar equator to a point about 15° or 20° from the solar north pole; near here, however, slight traces of elliptic polarisation were discernible. C. P. B.

REFERENCE.

1782. *Spectrographic Eclipse Results, Jan., 1898.* **W. W. Campbell.** (Astrophys. Journ. 11. pp. 226–233, April, 1900.)—This paper contains detailed particulars of apparatus used and photographs obtained during the total eclipse of the sun in India, 1898. [See also Abstract No. 456 (1900).] C. P. B.

LIGHT.

1783. *Electromagnetic Illustration of the Theory of Selective Absorption of Light by a Gas.* **H. Lamb.** (Cambridge Phil. Soc., Trans. 18. pp. 349–363, April, 1900.)—The subject of the scattering of waves by an insulated sphere has been treated by Rayleigh, Love, and G. W. Walker, always on the hypothesis that K, the dielectric constant of the sphere, is not very great. The present writer calls attention to the case in which K is a very large number. On this hypothesis two modes of free oscillation are possible whose wave-lengths in the surrounding medium are large compared with the periphery of the sphere, and which in general give rise to slow dissipation by the scattering of the waves. But when extraneous waves whose period is nearly coincident with that of a free oscillation encounter the sphere the divergent waves attain abnormal intensity.

A molecule being conceived as a sphere of this nature the author develops the theory mathematically. The results as stated by himself are principally as follows : For every period of free vibration there is a period, nearly coincident with it, of maximum dissipation for the incident waves. When the incident waves have precisely this period the rate of dissipation is, in terms of the energy flux of the primary waves, $\frac{2n+1}{2\pi}\lambda^2$, where λ is the wave-length and n the order of the spherical harmonic which is effective. Some results of this relation are pointed out. It is observed that a very minute change of λ enormously reduces the scattering. S. H. B.

1784. *Monochromatic Vision.* **W. de W. Abney.** (Roy. Soc., Proc. 66. pp. 179–180, April, 1900.)—An account of a case of monochromatic vision. The patient's luminosity curve is given. All colours he matched with white with the same facility as if they were white. The luminosity curve agrees very nearly with that of a similar case previously described, and attention is called to the fact that these curves are practically identical with those obtained by the normal eye when it measures a spectrum of very feeble luminosity, and also agree with the results obtained by measuring the diminution of each ray when it first becomes invisible, and making a curve of the reciprocals of the numbers. J. J. S.

1785. *Temperature Control of the Mills Spectrograph.* **W. W. Campbell.** (Astrophys. Journ. 11. pp. 259–261, May, 1900.)—After considering the great importance of securing uniformity of temperature of the spectrograph used in determinations of the velocity of stars in the line of sight at the Lick Observatory, the author describes the precautions he has adopted to secure these conditions. The instrument is encased in a double covering of woollen blanket, and then the whole enclosed in a cedar box lined with hair felt. In this box is distributed a length of German silver wire, connected with a rheostat and battery, by the regulation of which any variations of temperature may be at once corrected. The value of the installation is admirably shown by a table of the thermometer readings during an actual night's work of eight hours. While the temperature in the dome varied from 17·9° C. to 19·0° C., the extremes in the wooden box were 18·4° and 19·0°, and in the prism-box itself only 18·70° and 18·84°. C. P. B.

1786. *Ultra-Violet Absorption.* **B. Glatzel.** (Phys. Zeitschr. 1. pp. 285–287, March 31, 1900.)—The author determines absolute absorption co-efficients in the ultra-violet by means of Vierordt's double-refracting spar. The substance is put into a quartz trough and placed in front of one of the slits of the spar. Comparison of the two luminosities is made by photography, and the co-efficient of absorption is given by

$$a = -\frac{1}{d}\frac{\log\frac{i}{i'}}{\log e}$$

where d is the thickness of the film in mm., and i/i' the ratio of the

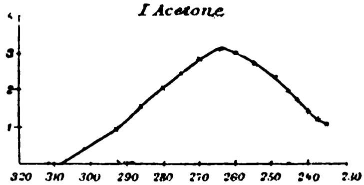


Fig. 1.

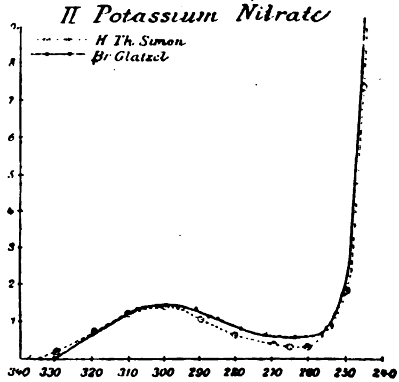


Fig. 2.

intensities. The diagrams embody the results for acetone and potassium nitrate, the latter being compared with the results given by H. T. Simon.
E. E. F.

1787. *Curvature of Spectral Lines in Spectroheliograph.* **W. S. Adams.** (Astrophys. Journ. 11. pp. 309–311, May, 1900.)—The use of a prismatic spectroheliograph for the Yerkes telescope necessitated a determination of the amount of curvature of the spectrum lines, so that the jaws of the slits could be properly made. The distortion in this case was specially great, as the slit had to be nearly *eight* inches in length to take in the whole of the solar image as projected by the 40-inch lens. After deducing the formula of curvature for a two-prism train, calculated and measured values of the distortion are given in a table.
C. P. B.

1788. *Specific Rotation of Sugar.* **O. Schönrock.** (Zeitschr. Instrumentenk. 20. pp. 97–118, April, 1900. Mittheilung aus der Physikalisch-Technischen Reichsanstalt.)—This is an accurate investigation of the temperature coefficient of the specific rotation of various kinds of sugar. The specific rotation is defined by the equation—

$$[a]_t = \frac{100a_t}{l_t p d_t}$$

where a_t is the rotation in degrees, l_t the length of the tube in decimetres, d_t

the density, and p the percentage of sugar in solution. The dependence upon the temperature is represented by the equation—

$$[\alpha]_t = [\alpha]_{20} \{l - \delta(t-20)\}$$

where δ is the temperature coefficient. This was found to vary between 0·000202 and 0·000232. The final formula for a nearly normal sugar solution is—

$$[\alpha]_t^D = [\alpha]_{20}^D - [\alpha]_{20}^D \, 0{\cdot}000277(t-20).$$

E. E. F.

1789. *Zeeman Effect.* **A. Righi.** (N. Cimento, 11. pp. 177–206, March, 1900. Mem. della R. Accad. di Bologna, December 17, 1899. Écl. Électr. 23. pp. 356–366, June 9, 1900.)—This is a theoretical and experimental investigation of the general case in which an angle ϵ of any value between 0° and 90° lies between the direction of the ray and the magnetic field which influences it.

For $\epsilon = 90°$ every ray emitted gives a triplet. The middle component is due to vibrations parallel to the lines of force, and its intensity is double that of the lateral components. The latter are due to vibrations normal to the field. When ϵ diminishes, the middle component also diminishes in intensity, but retains its state of polarisation. At the same time the brightness of the lateral components increases, and their vibrations become elliptical, in opposite senses, with their major axes normal to the meridian plane. When $\tan \epsilon = \sqrt{2}$, and $\epsilon = 54° \, 44'$, the three components of the triplet have equal intensities. When ϵ becomes still smaller, the middle ray diminishes further in brightness, while the brightness of the others increases. For $\epsilon = 0$ the middle ray disappears, while the lateral ones acquire their maximum intensity and are circularly polarised in opposite directions. All these changes are predicted theoretically by Lorentz's theory, or indeed by any theory which admits the existence, in a magnetic field, of a rotation about the lines of force of the medium in which the luminous vibrations have their seat. They are also fully verified experimentally. In the case of quadruplets, like the 4,800 cadmium line and the 4,722 zinc line, the two central components behave like the ordinary single component, and the outer components like the ordinary lateral components.

The author also verifies the theoretical data with respect to the Zeeman phenomenon as seen by absorption. No triplets are available for this verification, as no very fine triplets can be had. The author therefore employs the green ray of thallium, 5,351, and D_1, which give quadruplets, and D_2, which gives a sextuplet. As long as ϵ is greater than zero, D_1 and the thallium line give a quadruplet. As ϵ diminishes from 90° the two middle rays become less black and the external rays become more marked. Their behaviour is in fact strictly analogous to that of the normal triplet in the emission effect. In the matter of polarisation also, the lateral components show the circular and elliptical polarisations already described, as can be shown by means of a quarter-wave plate, which makes the right or left-hand component disappear according as it is right-handed or left-handed. In the sextuplet, the two outer pairs of lines behave like outer components of the normal triplet.

E. E. F.

1790. *The Law of Complete Radiation.* **Rayleigh.** (Phil. Mag. 49. pp. 539–540, June, 1900.)—By complete radiation is understood radiation from an ideally black body, which according to Stewart and Kirchhoff is a definite

function of the absolute temperature θ and the wave-length λ. The energy of that part of the spectrum which lies between λ and $\lambda + d\lambda$ should be of the form $\theta^5\phi(\theta\lambda)d\lambda$ according to Boltzmann and W. Wien, and according to Wien's later result, $c_1\lambda^{-5}\epsilon^{-c_2/\lambda\theta}d\lambda$. The author suggests, from considerations connected with the law of partition of energy, a modification of the above, namely, $\theta\lambda^{-4}d\lambda$ instead of $\lambda^{-5}d\lambda$, but leaves the question to be settled by experiment.
S. H. B.

1791. *Anomalous Dispersion in the Faraday Effect.* **A. Schmauss.** (Ann. d. Physik, 2. 2. pp. 280–294, June, 1900.)—The author tests whether the magnetic-rotatory dispersion in substances showing anomalous optical dispersion also shows discontinuities in the neighbourhood of the absorption bands. The substances examined were fuchsine and cyanine dissolved in alcohol, didymium glass, and the fluorescent dyes, eosene and naphthaline red. Rather dilute solutions were employed, so as to be able to follow the existing anomalies into the absorption bands themselves. Wiedemann's method was employed, but with the addition of an aragonite crystal, so that the rotation was indicated by the position of the area devoid of interference fringes. These fringes could be plainly made out within the absorption bands themselves when the latter were not too dark.

The results show that the general form, which Kundt gave to the law of optical dispersion, can also be applied to the dispersion observed in the Faraday effect. Proceeding from the red to the violet, the rotation increases very rapidly just before the absorption band is reached, decreases rapidly within it, and increases again after the band is passed. In strongly absorbing media the anomalous dispersion extends over a considerable region on both sides of the absorption band, and the anomaly increases with the concentration. It also increases with the sharpness of the absorption band. The rapid rise of the curve of rotatory dispersion in ordinary media is due to the existence of an absorption band in the ultraviolet. The anomalies observed are so considerable that they form a useful criterion for the existence of an absorption band where the eye is incapable of perceiving it. Thus, according to Vogel, cyanine shows a slight absorption between D and E in an aqueous solution, but not in an alcoholic solution. The author found indications of an absorption band in his alcoholic solution of cyanine, and was able to trace it to a slight admixture of water in the commercial "absolute alcohol" used.
E. E. F.

1792. *Band Spectrum of Aluminium.* **G. A. Hemsalech.** (Ann. d. Physik, 2. 2. pp. 331–334, June, 1900.)—The author describes some experiments which confirm Aron's view that the band spectrum of aluminium is due to the metal itself, and not to the oxide. With the ordinary induction spark the bands are not obtained very clearly if the gap is large. On introducing a condenser, the bands are obscured by the very bright line spectrum of the air, which with aluminium electrodes comes out very prominently. If the spark is made horizontal, and its image is projected on to the slit of a spectroscope, the air spectrum and the high-temperature aluminium lines appear in the middle, and the band-spectrum above and below. The air spectrum can be eliminated by introducing an inductance coil without iron core, and then the bands appear in great intensity. These bands are also seen when the spark passes in an atmosphere of hydrogen or nitrogen. The bands are most vivid in oxygen, because then the spark is strongest, and vapour is freely evolved. In none of the cases do the electrodes show any sign of oxidisation. E. E. F.

1793. *Influence of Impurities upon Gaseous Spectra. II.* **P. Lewis.** (Ann. d. Physik, 2. 3. pp. 447–458, July, 1900.)—Having previously studied the effect of admixtures of mercury, water vapour, and oxygen upon the spectrum of hydrogen [see Abstract No. 468, 1900], the author proceeds to study the effect of the same impurities upon the spectrum of nitrogen. This is reduced by the presence of mercury, but not in such a pronounced and regular manner as is the hydrogen spectrum. Oxygen brings about a general reduction of intensity, while water vapour in any considerable quantity suppresses the red, yellow, and green bands entirely, and reduces the blue bands. E. E. F.

1794. *Absolute Determination of Spectrum Wave-lengths.* **L. E. Jewell.** (Astrophys. Journ. 11. pp. 234–240, April, 1900.)—This is a reply to a statement made by E. B. Frost [see Abstract No. 457, 1900] that the effect of the rotation of the earth on its axis, and the eccentricity of the earth's orbit, upon the wave-lengths of the lines of the solar spectrum, had never been taken into consideration. The corrections due to these causes, however, are so small that it is useless to apply them to determinations in which the errors of observation are considerably greater. C. P. B.

1795. *Titanium for Comparison Spectra.* **L. E. Jewell.** (Astrophys. Journ. 11. pp. 243–244, April, 1900.)—E. B. Frost has previously pointed out the convenience of using the spark spectrum of titanium as a standard for comparison with stellar spectra. [See Abstract No. 56, 1900.] The present author points out its occurrence in the spectrum of the solar chromosphere, the lines at $\lambda\lambda$3685·339, 3759·447, 3761·464 being specially prominent. C. P. B.

1796. *Luminosity Curve of Solar Spectrum.* **D. W. Murphy.** (Astrophys. Journ. 11. pp. 220–225, April, 1900.)—The author commences by stating the difficulties involved in photometric comparisons of lights of different colours, enhanced by individual personal error. His own work has been done with a Lummer-Brodhun spectrometer, and part of the difficulty of colour contrast eliminated by making the comparisons between small portions of the spectrum very close to each other, the difference in tint being thereby a minimum. The most constant source of illumination was found to be the open sky during June and July. After adjusting the two comparison spectra to equality, the movable collimator, having a slit of constant width (0·25 mm.) was moved in progressive steps of an angular value equal to that subtended by this slit width, thus bringing successive small portions of the spectrum into comparison with the standard. The varying widths of the other slit necessary to produce equality of intensity were then noted. In this manner the spectrum was measured from λ 6880 to λ 4500, and the results are given in two tables and also plotted as curves. C. P. B.

1797. *Production of Röntgen Rays by a Battery Current.* **J. Trowbridge.** (Amer. Journ. Sci. 9. pp. 439–441, June, 1900.)—The author has lately completed the installation of a plant of 20,000 storage cells in the Jefferson Physical Laboratory. This places at his disposal an E.M.F. of over 40,000 volts, and a comparatively steady current through a large resistance. He has succeeded in obtaining Röntgen rays of exceptional brilliancy with the aid of this E.M.F., which, moreover, yield negatives of great contrast, showing traces of the shadows of ligaments and muscles. The great advantage of this new method of generating the rays is the possibility of exactly regulating the

current and difference of potential which is necessary to excite the rays. This is not possible by any of the methods hitherto used. When the Röntgen ray tube is first connected to the battery terminals no current flows; it is necessary to heat the tube with a Bunsen burner. At a certain critical temperature the tube suddenly lights up with a vivid fluorescence, and the rays are then given off with great intensity. The author employed a distilled-water resistance of about 4,000,000 ohms. This places it beyond a doubt that no electrical oscillations had any part in the production of the Röntgen rays. E. E. F.

1798. *Diffraction of Röntgen Rays.* **A. Sommerfeld.** (Phys. Zeitschr. 1. pp. 105–111, 1899.)—Mathematical discussion of the theory of single impulses at irregular intervals: applicable also to a certain extent to noises in the theory of sound. A peculiar wave-form is traced out and illustrated. Shadows are absolutely sharp for infinitely short impulses: in other cases there is a certain amount of diffraction, but at the shadow boundary there is no succession of maxima and minima as in optics, but a steady fall off, more or less steep. The shorter the impulses the less the absorption: so that the Röntgen rays best adapted for radiography are the worst adapted for the study of diffraction. The more deliberate impulses associated with lower vacua and correspondingly smaller velocities of the kathode rays would be better for diffraction-phenomena: those in the highest vacua should show none. The amount of diffraction is so related to the spread of disturbance upon the anti-kathode surface during the impulse that a table could be drawn showing the values of the latter corresponding to observed values of the former as shown by the photographic plate. The amount of diffraction observed by Haga and Wind [Amsterd. Acad., April, 1899, p. 420; Wied. Ann. 68. p. 884, 1899; Abstract No. 1871 (1899)] corresponds to a spread of $\frac{1}{5}\ 10^{-7}$ cm. from the centre during the impulse. This datum is not in disaccord with Lord Kelvin's estimate of the diameter of molecules if we take into account J. J. Thomson's result, that the spread of the impulse must be not less than the diameter of the molecule and is only in a limiting case so small as to be merely equal to it. A. D.

1799. *Diffusion of Röntgen Rays through Solids.* **H. Dufour.** (Phys. Zeitschr. 1. pp. 202–203, Feb. 3, 1900.)—When the base of an oblique prism of wood is exposed to Röntgen rays, photographic effects can be obtained from the opposite end, although that end may not be at all in the direct line of the rays. The effects are then due to secondary rays diffused in all directions through the body of the wood, and emerging in a diffused manner from the whole of its surface. The same effect may be obtained from paraffin and also from troughs filled with petroleum or some other liquids. The secondary rays emerge from the other surfaces, including those which are normal to the direction of incidence. E. E. F.

1800. *Röntgen Rays and Evaporation.* **E. Pasquini.** (N. Cimento, 11. pp. 133–135, Feb., 1900.)—The author finds no appreciable effect produced by Röntgen rays in influencing evaporation. A. D.

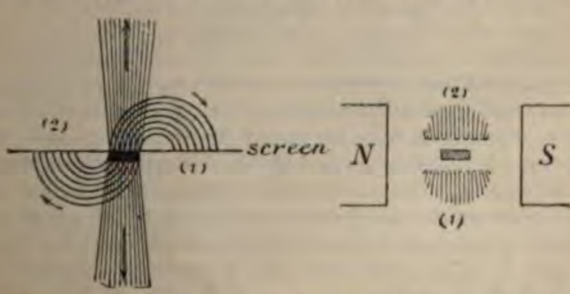
1801. *Duration of Röntgen Radiations.* **B. Brunhes.** (Comptes Rendus, 130. pp. 1007–1010, April 9, 1900.)—Further experiments, of the Wheatstone and Arago type. The period of emission under a spark is of the order of the ten-thousandth of a second. Traversing 35 cm. of air does not appear to affect the length of the train of waves; kathode rays behave differently. A. D.

1802. *Radiations of Radio-active Bodies.* **M.** and **Mme. Curie.** (Soc. Franç. Phys., Bull. 145. pp. 3–4, 1900.)—At the temperature of liquid air, radio-active bodies continue to excite fluorescence in uranyl-potassium sulphate. Radiferous $BaCl_2$ becomes more luminous at that temperature. Those radiations from radium which are not deviable in a magnetic field do not travel more than 7 cm. in air. Polonium only emits non-deviable rays, and these can only travel 4 cm. in air. Giesel's polonium, on the contrary, emits both deviable and non-deviable rays. The rays from radium carry negative charges, which cannot, however, be detected if air be the medium, since this is rendered conductive by the rays. These charges are small; about 10^{-11} coulombs per second from 2·5 sq. cm. of radiferous chloride of barium. A. D.

1803. *De-ionisation of Air.* **E. Villari.** (Accad. Lincei, Atti, 9. pp. 288–295, May 6, 1900.)—Air ionised by Röntgen rays loses its conductivity more rapidly when passing through a twisted metallic tube than the same length of a straight tube. It may be rapidly de-ionised by passing it through a bundle of copper wires. The tubes which de-ionise the air often take a high positive charge, which may attain an E.M.F. of some 40 volts. E. E. F.

1804. *Secondary Röntgen Rays.* **J. S. Townsend.** (Cambridge Phil. Soc., Proc. 10. pp. 217–226, Jan., 1900.)—The secondary radiation which extends to a distance from the body emitting it does not come directly from the surface but must be considered as emanating from the substance of the material. There is also another radiation rapidly absorbed by the gas near the surface of the radiating body; at atmospheric pressures the effect of this radiation is hardly appreciable at distances greater than 5 mm. from the surface. The latter radiation gives rise to Perrin's surface effect; the former produces ionisation at a distance. The rate of absorption of radiation by a gas appears proportional to the ionisation. The number of ions produced in a given volume is $S \times p D$, where S is the effect of the surface rays, p the pressure, and D a constant depending on the direct rays. When the pressure is reduced the absorption of the secondary rays is reduced proportionally, so that the surface rays come to extend across the vessel containing the gas, part of their energy then being absorbed by the opposite wall. A. D.

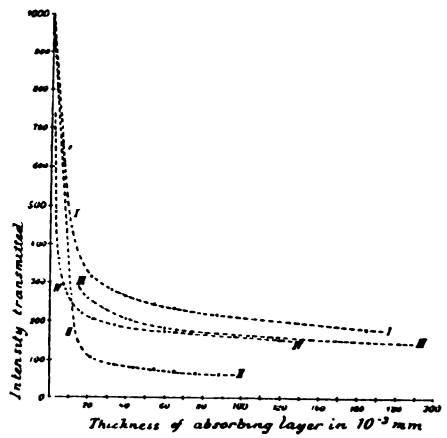
1805. *Radium and Polonium Rays.* **S. Meyer** and **E. R. v. Schweidler.** (Phys. Zeitschr. 1. pp. 90–91, and 113–114, 1899.)—The molecular magnetic



susceptibility of one of Giesel's radium preparations is found to be $-0·08 \times 10^{-6}$, a value which is so near the value for pure barium chloride that no conclusion can be drawn as to the magnetic properties of pure radium, supposing

such a substance to exist. The radiation of the same preparation is considerably enfeebled by a magnetic field whose lines are at right angles to the electric lines of force, the radiation amounting to some 80 per cent. in a field of 17,000 units. Under the same circumstances, a radium preparation by Curie only shows a radiation amounting to 15 per cent., and polonium preparation none at all. This magnetic effect has more recently been explained as due to the magnetic deflection of the rays in question. The authors describe deflection effects similar to those attained by the Curies and by Becquerel. Thus, in a magnetic field due to the poles N.S., the radium rays produce two luminous patches, one on each side of the centre line joining the poles, and due to the curving round of the rays ordinarily proceeding upwards and downwards (see diagram). E. E. F.

1806. *Absorption of Radium Rays.* **S. Meyer** and **E. R. v. Schweidler.** (Phys. Zeitschr. 1. pp. 209–211, Feb. 10, 1900.)—In order to investigate the various degrees of absorption undergone by radium rays from different sources (see preceding Abstract), the authors examined the absorptivity of a number of metals for the rays from a radia-active barium chloride and bromide prepared by Giesel, and a carbonate prepared by Curie. The transmissions are plotted in the annexed diagram, where curve I gives the luminosities transmitted by tin in the case of Curie's preparation, III by palladium, IV by platinum, and II the tin curve of Giesel's preparations. It will be seen that the first few hundredths of a mm. are the most effective in the absorption, and



it may be concluded that in the case of radium rays, as in Röntgen, uranium, and thorium rays, the radiation consists of a large number of rays of different nature. The absorptions were measured by the electroscope method, and can therefore not be directly applied to other effects such as fluorescence or photographic action. The connection between fluorescence and electric ionisation is very irregular. Substances cannot be arranged according to their absorptive powers, as they vary with the thickness. For a thickness of 50×10^{-3} and Curie's preparation, the succession is: paper, aluminium, tin, copper, palladium, platinum. E. E. F.

1807. *Radiations from Radium.* **H. Becquerel.** (Comptes Rendus, *130.* pp. 809–815, March 26, 1900.)—M. and Mme. Curie have shown that the

radiations from radium carry negative electric charges. They therefore, like kathode rays, probably depend on the transport of matter. Measurements of the electrostatic deviation in a magnetic field are difficult ; details are given. From the results of these measurements, with calculations of the trajectories, it appears that the velocity $v = 1{\cdot}6 \times 10^{-10}$, and the mass charge ratio for the molecules, $m/e, = 10^{-7}$, quantities of the same order as in the case of kathode rays. And on taking into account M. and Mme. Curie's value for the rate of loss of charge, it follows that the energy radiated per sq. cm. is about 5 ergs per second and the quantity of matter lost per sq. cm. is about one milligramme in a milliard years. A. D.

1808. *Radium Radiations.* **H. Becquerel.** (Comptes Rendus, 130. pp. 979–984, April 9, 1900.)—It appears that on traversing aluminium or black paper these radiations retain their velocities and their charges, or at least that the product mv/e varies little ; though there are some phenomena which point in a contrary direction. A. D.

1809. *Radium Radiations.* **H. Becquerel.** (Soc. Franç. Phys., Bull. 148. p. 4, May 4, 1900.)—Radium radiations are of three kinds—a part deviable by a magnetic field ; a part non-deviable and readily absorbed ; and a part weaker and diffused, non-deviable, attributable partly to secondary rays. A. D.

1810. *Radium Radiation at Low Temperatures.* **O. Behrendsen.** (Ann. d. Physik, 2. 2. pp. 335–337, June, 1900.)—The activity of a radium preparation was tested at ordinary temperatures, and at the temperature of liquid air, by the electrometer method. It was found that the cooling of the preparation reduced its radio-activity by more than one-half. On heating it up again to the normal temperature, a slight increase of radio-activity was discovered. This is quite in agreement with the behaviour of phosphorescent bodies as described by Lumière. The author also remarks that the polonium sublimates prepared a year ago have lost a considerable part of their radio-activity. Giesel makes the same remark concerning his own polonium preparations. E. E. F.

1811. *Uranium Radiation.* **H. Becquerel.** (Comptes Rendus, 130. pp. 1583–1585, June 11, 1900.)—Two different kinds of Becquerel rays have up to the present been discovered. One kind has practically all the characteristics of kathode rays, and is deflected by both magnetic and electric forces. The other kind is not deflected by either, and shows various degrees of absorption by metals and other opaque substances. Radium emits both kinds of rays. Polonium only emits the second kind, while Debierne's "actinium" only emits kathode rays. The author endeavours to determine the exact nature of the rays emitted by uranium, the first substance which was found to emit the rays named after him. The difficulty of operating with uranium lies in the feebleness of its radiation. He found, however, that the rays emitted were deflected to about the same extent as the most penetrating radium rays. That might be explained by the supposition that uranium contains an admixture of radium, and that the true uranium rays are feebler. But the author believes that these deflected rays are due to actinium. They can be removed by treating the uranium chloride with barium chloride. Radio-active barium sulphate is produced, and a purified uranium salt remains. Further purification makes no difference, and hence it is probable that uranium has a definite though feeble radiation of its own. E. E. F.

HEAT.

1812. *Specific Heat of Wheat-Starch as a Function of its Water-content and of the Temperature.* **H. Rodewald** and **A. Kattein.** (Zeitschr. Phys. Chem. 33. pp. 540–544, June 1, 1900.)—The method of measuring the specific heat is that formerly described by Rodewald, the starch being contained in sealed tubes of Jena glass. For starches containing different quantities of water the following are the specific heats calculated on the dry substance :—

Percentage of water ...	0	9·38	15·79	18·52	29·26	33·66
Specific heat	0·2697	0·2579	0·2603	0·2580	0·3081	0·3054

The temperature-coefficients of the specific heats are also given. These results show that no such relation exists for starch as was found by Volbehr for wood-fibre, the specific heat of which changes proportionally with its water-content and with the temperature. T. H. P.

1813. *Volume and Pressure of Saturated Vapour.* **H. Moulin.** (Comptes Rendus, 130. pp. 1454–1457, May 28, 1900.)—If ϵ is the difference between the coefficients of linear expansion of the molecule and its nucleus at constant pressure, and ϵ' the same under constant volume, and we put $\gamma = \epsilon T_c$ and $\gamma' = \epsilon' T_c$, the following formulæ may be obtained for the pressure and volume of any saturated vapour, as compared with those of a standard substance H—

$$\frac{v}{v_c} = \left(\frac{v}{v_c}\right)_H \left[1 + \gamma\left(1 - \frac{T}{T_c}\right)\right]^3$$

$$\frac{p_c}{p} = \left(\frac{p_c}{p}\right)_H \left[1 + \gamma'\left(1 - \frac{T}{T_c}\right)\right]$$

The author verifies these formulæ for a number of organic substances, and finds γ always to lie within the limits 0·2 and 0·5. E. E. F.

1814. *Tension of Saturated Mercury Vapour.* **L. Cailletet, Colardeau,** and **Rivière.** (Comptes Rendus, 130. pp. 1585–1591, June 11, 1900.)—The authors have pushed to the furthest attainable limits the study of the vapour tension of mercury as the most accessible of metallic vapours. The mercury is contained in two strong coaxial iron tubes communicating with a high-pressure cylinder. When the tubes are heated mercury vapour forms in the lower parts, and its pressure is transmitted by the cylindrical layer of mercury which remains in the portion between the two cylinders. The experiments gave results in good agreement with Regnault's values, but the authors did not succeed in their main object, that of reaching the critical temperature of mercury, owing to the fact that at a red heat mercury is transmitted freely through the substance of the iron. The following are some of the pressures obtained :—

Temperature	400°	500°	600°	700°	800°	850°	880°
Pressure (Atmos.)	2·1	8	22·3	50	102	137·5	162

E. E. F.

1815. *Convection Movements.* **H. Bénard.** (Comptes Rendus, 130. pp. 1004–1007, April 9, and pp. 1065–1068, April 17, 1900.)—A thin layer of liquid heated by a uniform flux of heat from below may assume a stable condition, in which it is broken up into regular polygonal prismatic cellules, in each of which there is an axial ascent and a peripheral descent. The perfection and the permanence of the forms assumed are remarkable. Methods of observation: movement of dust and distribution of it, viewed from above as a transparency; position assumed by reflecting lamellar dust; deposition of dust at the centre of each cellule; travel of floating dust to the periphery of each cellule; optical study of surface depressions (about 1μ for liquid depth 1 mm.) best by treating the cellules as lenses. A. D.

1816. *Thermography.* **R. E. Liesegang.** (Phys. Zeitschr. 1. p. 317, April 14, 1900.)—If equal quantities of hydroquinone and anhydrous sodium carbonate be rubbed together with just sufficient alcohol to wet the powder, a mass is obtained which turns dark blue after a few minutes. If this mixture be painted on a piece of thin note-paper and then rubbed off, it will be found that the blue-coloured paper so obtained is very sensitive to long heat-waves. Thus on exposure for five seconds to the radiation of a gas stove the blue colour is completely bleached. Shadows of coins can be obtained in this way. This sensitive paper is not, however, very durable. F. G. D.

1817. *Kinetic Theory of Gases.* **Z. Gyözö.** (Ann. d. Physik, 2. 2. pp. 404–413, June, 1900.)—The kinetic theory has been based upon an assumption which can be formulated as follows: That one molecule should at any time have certain velocity components, and that another molecule should have certain other velocity components at the same time, constitutes two phenomena which from the theory of probability are entirely independent of each other. Burbury has endeavoured to free the kinetic theory from this assumption, and has pointed out the necessity of formulating a new theory, since the above assumption cannot continue in time, and conclusions drawn from it lead to contradictions. The author shows that these contradictions are only apparent, and that the formulation of a new theory, however desirable, is not called for by them. The author deals more particularly with the definition of the density and the "streaming velocity" of an aggregation of molecules. E. E. F.

1818. *Thermal Radiation in Absolute Measure.* **J. T. Bottomley** and **J. C. Beattie.** (Phil. Mag. 49. pp. 543–557, June, 1900; Roy. Soc., Proc. 66. pp. 269–282, May 12, 1900.)—Currents of different strengths were passed through two platinum wires in series, which had the same length and diameter but different surfaces (the one being left bright and the other being thinly coated with soot), and which were enclosed in glass tubes with the same vacua. The difference of potential of the ends of a wire, together with the current, gave its resistance, and hence (by a previous determination) its temperature and also its emissive power (C^2R/JS), which was plotted against the temperature. The temperatures ranged from 15° to 743° C. Three pairs of wires were experimented on, of respective diameters 0·0542, 0·025, and 0·015 cm., and for temperatures higher than 200° the average ratios of the emissive power of the wire with sooted surface to that of the bright wire were found to be respectively 5, 4·76, and 4·1. R. E. B.

1819. *Two Theorems of Gibbs'.* **P. Saurel.** (Journ. Phys. Chem. 4. pp. 193–199, March, 1900.)—The equivalence of Gibbs' equation—

$$v_r dp = \eta_r dt + \sum_1^n m_n d\mu_r,$$

for univariant systems with the Clapeyron-Clausius formula, $dp/dt = H/t(v' - v)$, is here demonstrated for the general case of n components, and also the conditional equivalence for bivariant systems. R. E. B.

1820. *Reduction of Problems of Heating by Radiation to that of Heating by Contact. Heating of a Wall of Infinite Thickness.* **J. Boussinesq.** (Comptes Rendus, 130. pp. 1579–1583, June 11, 1900.)—For equilibrium of temperature of two substances in contact we require $u = u_e$, where u is the temperature of one, which may be called the internal, u_e that of the external body. If the exchange of temperature between the internal body and the external space takes place by radiation, we have an equation similar in form, namely, $\phi = u_e$, in which—

$$\phi = u + G\frac{du}{dx} + H\frac{du}{dy} + I\frac{du}{dz},$$

when K denotes the internal conductivity, and G, H, I are $K\cos\alpha$, $K\cos\beta$, $K\cos\gamma$, and $\cos\alpha$, $\cos\beta$, $\cos\gamma$ are direction cosines of the normal.

Internally we have $\frac{du}{dt} = a^2\nabla^2 u$, or $\nabla^2 u = 0$, according as u is constant or not. If the initial temperature at x, y, z is $f(x, y, z)$ or f, we have—

$$\phi = f + G\frac{df}{dx} + H\frac{df}{dy} + I\frac{df}{dz},$$

and for constant temperature $\phi = f$. The function ϕ is determined by equations identical with or analogous to those which determine u in heating or cooling by contact. The author gives examples of the theory worked out mathematically. S. H. B.

1821. *Permanent Changes and Thermodynamics.* **P. Duhem.** (Zeitschr. Phys. Chem. 33. pp. 641–697, June 15, 1900.)—The writer investigates systems depending on two variables, of which one only is affected by hysteresis. In this paper he collects the results of certain of his former memoirs. [See Abstract No. 1228 (1898) and Abstract No. 1354 (1899).] In an introductory chapter he supposes a system defined by three normal variables: (1) the absolute temperature T; (2) the specific volume v; and (3) a variable x which he calls the chemical variable, which, however, according to the form of a certain inequality, is subdivided for the sake of distinction into x variables and ν variables. If $f(v, x, T)$, or shortly f, denote the internal thermodynamic potential, U (v, x, T) the internal energy, S (v, x, T) the entropy, we have the known equation—

$$f = U - TS.$$

And if π denote external pressure, the conditions for equilibrium are—

$$\frac{df}{dv} + \pi = 0$$

$$\frac{df}{dx} = 0$$

The conditions for stability are deduced from these. The author then for-

mulates three laws: (1) The law of variation of the position of equilibrium at constant temperature, viz., "Every increase of pressure taking place reversibly and at constant temperature changes the position of equilibrium in such a way that the specific volume diminishes." (2) The law of variation of the position of equilibrium with change of pressure. This gives rise to two cases according as $\frac{d^2f}{dvdx} > \text{or} < 0$. In the second case the chemical variable x is distinguished as a y variable. (3) The law of variation of the position of equilibrium with change of temperature. The condition of the thermodynamic potential under constant pressure is also discussed.

In the first chapter is treated the case in which the variable v alone is affected by hysteresis.

In the second chapter the variable x (*i.e.*, x or y) alone is affected by hysteresis, and in paragraph (1) the foundation of the theory is explained on this hypothesis; and in (2) the x and y variables are distinguished. In paragraph (3) the author treats of isothermal variations, with two assumptions, namely—(*a*) For given T and x, v diminishes as π increases; (*b*) every isothermal variation is subject to the law (2) of the introduction. Paragraph (4) deals with isobaric variations. The author assumes, thirdly, that every isobaric variation is subject to law (3) of the introduction. Next in paragraph (5) are discussed closed cycles and "natural states," and the distinction is drawn between systems of the first or second kind according as for a certain function ϕ, $\frac{d\phi(x,\pi,T)}{dx} > \text{or} < 0$.

The writer then, in paragraph (6), defines pseudo-reversible processes as those in which throughout a cycle of changes the system is always in a natural state, but at the end π and T return to their initial values. He makes with respect to these a fourth assumption, viz., every pseudo-reversible process fulfils Clausius' equation, $\int\frac{dQ}{T} = 0$. In paragraph (7) is discussed Clausius' inequation (*Ungleichung*), and we have a fifth assumption, viz.: In every possible irreversible process Clausius' inequation, $\int\frac{dQ}{T} > 0$, is satisfied.

In the application of the theorems to isothermal variations, paragraph (8), a sixth assumption is made, viz.: The neighbourhood of a natural state is for a system of the first kind when for a certain function Ω (the apparent thermodynamic potential under constant pressure π)—

$$\frac{d^2\Omega}{dx^2} > 0$$

for a system of the second kind when—

$$\frac{d^2\Omega}{dx^2} < 0$$

He then in paragraph (9) discusses the law of the variation of the natural state by pressure; in (10) by change of temperature; in (11) the conditions for the fulfilment of Clausius' inequation throughout an isothermal process; and (12) throughout an isobaric process. Paragraph 13 deals with the position of a simple cycle with respect to the series of natural states, and paragraph (14) with isobaric variations. S. H. B.

SOUND.

1822. *Pitch of Galton's Whistles.* **M. T. Edelmann.** (Ann. d. Physik, 2. 3. pp. 469–482, July, 1900.)—The author gives a new form of Galton's whistle, in which the blast from a ring-shaped mouthpiece impinges upon the sharp edge of the pipe, which is also circular, and can be brought to within any desired small distance from the mouthpiece. This whistle gives very strong notes, whose pitches are studied by means of Kundt's dust figures. It is found that the highest limit of hearing is a little beyond 50,000 complete vibrations per second. By making the diameter of the pipe as small as 2 mm., the author has succeeded in constructing pipes giving the very high pitch of 170,000 vibrations per second. E. E. F.

1823. *Perception of Pure Notes.* **W. Heinrich.** (Acad. Sci. Cracovie, Bull. pp. 37–45, Jan., 1900.)—The author quotes a number of experiments which show that in a pure note which is just perceptible to the ear no variations of intensity are heard, even though the note should itself vary in intensity at the source. This is all the more remarkable as such variations of intensity can be expected to result from the pulsation of the blood-vessels and the corresponding variation of the tension on the ear-drum [see following Abstract]. When the sound heard is not a pure note, but a slight noise, such as the ticking of a watch, the ear is able to perceive the difference of intensity. The author does not hazard an explanation. E. E. F.

1824. *Function of the Ear Drum.* **W. Heinrich.** (Acad. Sci. Cracovie, Bull. pp. 105–111, March, 1900.)—To every tension of the ear-drum there belongs a single note to which it responds. Any note of a different pitch produces no effect. This is made evident by distending the ear-drum in an interference apparatus, when the fringes only disappear on sounding the proper note. The note may be changed by changing the tension of the membrane. The author regards the ear-drum as an organ capable of accommodation. It does not respond to irregular noises, and the mechanism of their transmission is not yet explained. E. E. F.

1825. *Sensitive Flames and Difference Tones.* **N. Schmidt.** (Deutsch. Phys. Gesell., Verh. 2. 2. pp. 22–23, 1900.)—A glass tube drawn out at the end to about 1–1·5 mm. diameter, and supplied with gas at a pressure of about 15 cm. of water, gives a flame at the nozzle about 40–60 cm. long which is very sensitive to noises or tones of a certain pitch.

If two Galton whistles are sounded in the neighbourhood the flame acts just as it would for one so long as the whistles agree in pitch, but when the pitch of one is altered the flame begins to *resound* to the "difference tone." This is at first evident to the eye, and as the difference increases the vibrations are seen to become quicker and quicker until they become audible to the ear as a low note, and they can then be followed by the ear quite distinctly until their frequency reaches two to three thousand. J. B. H.

1826. *Transverse Vibrations of India-Rubber.* **T. J. Baker.** (Phil. Mag. *49. pp.* 347–351, April, 1900.)—The pitch of the note produced by twanging

an indiarubber band which is stretched over the fingers is influenced but little by the tension, particularly if this is considerable. Measurements of the pitch of the note produced under various tensions, as well as the variations of length and sectional area, show that in indiarubber Young's modulus is proportional to the square of the stretched length of the cord. That being so, the author proves theoretically that the frequency of a greatly stretched indiarubber cord will increase very slowly with the increase of tension. The formula deduced for the relation between the pitch n, the natural length l, and the stretched length L is—

$$n \propto \sqrt{\frac{L - l}{L}},$$

which gives a very slow increase of n with L when the latter is large.

E. E. F.

1827. *Vibration of a String under a Moving Force.* **M. Radaković.** (Akad. Wiss. Wien, S.ber. 108. pp. 577-612, 1899.)—In the motion of a train over a bridge, the latter is subjected to two kinds of forces whose point of application is displaced. One of them is the moving weight of the train, the other is the succession of impulses produced by the rotation of the main wheels of the engine and the crossing of rail joints. The full theoretical discussion of these impulses has never been carried out, though Stokes, Willis, Boussinesq, and Steiner have treated certain restricted problems in connection with it. The author, therefore, attempts the mathematical discussion of a simplified problem, that of the vibration of a string excited by a series of impulses, and carries it out completely. In doing so, he uses in the first instance d'Alembert's integral, but also employs that of Bernouilli, which indicates a method of solution capable of being applied to other vibrating systems, notably to a rod vibrating transversely.

E. E. F.

REFERENCES.

1828. *Tuning-forks.* **A.** and **V. Guillet.** (Comptes Rendus, 130. pp. 1002–1004, April 9, 1900.)—Method of keeping up the vibrations of a tuning-fork by connecting it with a microphone and adjusting. A. D.

1829. *Problems in Acoustics.* **C. K. Wead.** (Science, 11. pp. 732–735, May 11, 1900. Paper read before the Washington Philosophical Society.)—A brief report from the Committee on Physical Science on the present state of acoustics.

ELECTRICITY.

THEORY AND ELECTROSTATICS.

1830. *Distribution of a Gas in an Electric Field.* **G. W. Walker.** (Phil. Mag. 49. pp. 529–538, June, 1900. Paper read before the Physical Society of London.)—The author supposes a gas consisting of diatomic molecules and also of dissociated atoms. Of the two atoms forming a molecule, one has a positive charge e of electricity, the other the corresponding charge $-e$. The free atoms are supposed to retain the same charges e and $-e$. The positive and negative atoms are not assumed to be equal in number per unit of volume.

The author investigates the mathematical properties of a medium so constituted, with reference to pressure, density and electric force, or current. He supposes that the recombination of positive and negative atoms to form a molecule gives rise to luminosity. If the regions of maximum density of matter coincide with those of least electric density, that is where the numbers of atoms of the two classes are equal; it is here that we should expect the greatest luminosity. This state of things is closely related to the phenomena of a striated vacuum tube. It is discussed in that relation and with reference to a result obtained by Goldstein (Wied. Annalen, xv. p. 277, 1883), and some experiments of R. S. Willoughs, at the Cavendish Laboratory. S. H. B.

1831. *Poynting's Hypothesis.* **P. S. Wedell-Wedellsborg.** (Zeitschr. Phys. Chem. 33. pp. 631–635, June 1, 1900.)—The author criticises Poynting's hypothesis which assumes that the electric tubes of force move at right angles to themselves into a conductor carrying a current, and are then converted into heat. He claims that this hypothesis contradicts the conservation of energy and the proportionality between potential and electric density at constant current. He points out that if it were true, a current gradually increasing in a solenoid would increase its own intensity without limit.

E. E. F.

1832. *Conservation of Electricity.* **O. M. Corbino.** (N. Cimento, 11. pp. 136–140, Feb., 1900.)—Lippmann showed (Ann. de Chimie et de Phys. 5 ser. t. 24, p. 159, 1881) the importance of the principle of conservation of electricity. The author here criticises Lippmann's formulæ on the ground that certain functions are considered as exact differentials when they are not necessarily so. Sacerdote's formulæ, as far as they go, are not open to this objection. A. D.

1833. *Ionic Theory of Metals.* **P. Drude.** (Phys. Zeitschr. 1. pp. 161–165, Jan. 6, 1900.)—Electric conduction in metals may be considered as due to the transportation of ions, and this view leads to a simple explanation of the optical characters of metals which is free from contradictions and complicated assumptions. Since there is no visible transportation of masses, it may be assumed, with Giese, that the metallic ions convey the current only through very short distances, after which they pass on their charges to neighbouring ions. Leaving this process of transfer out of account, and supposing all ions

capable of conveying electricity to have an equal mass, the current in a metal subjected to a constant electric force may be regarded as due to the wandering of ions of constant mass and constant charge with a certain constant average velocity. Let the number of these ions per unit of volume be N. There must be several kinds of ions, two at least, for there is no free charge, and we have, therefore,

$$\Sigma \mathrm{N}e = 0 \tag{1}$$

when e is the elementary charge.

Regarding for the present only one kind of ions, and denoting by ξ, η, ζ the components of the displacement of an ion from its position of rest, we have in case of a constant electric force X

$$\frac{\partial \xi}{\partial t} = ve\mathrm{X} \tag{2}$$

This equation can be interpreted as meaning that under the influence of a friction proportional to $\frac{\partial \xi}{\partial t}$ the ion acquires a constant velocity under a constant force X. If X changes, the equation of motion of the ion becomes

$$m\frac{\partial^2 \xi}{\partial t^2} = e\mathrm{X} - \frac{1}{v}\frac{\partial \xi}{\partial t} \tag{3}$$

The quantity $\frac{1}{v}$ may be called the friction of the ion, and v its mobility; v is really the velocity which the ion assumes under the permanent influence of one dyne.

If we introduce the additional assumption that the ion is driven back to its position of equilibrium by a force proportional to ξ, the equation of motion would be

$$m\frac{\partial^2 \xi}{\partial t^2} = e\mathrm{X} - \frac{1}{v}\frac{\partial \xi}{\partial t} - p\xi \tag{4}$$

This would have to be done in order to explain the optical properties of insulators. In that case the displacement ξ is finite. If in the course of this displacement the ion does not meet another to which it can communicate its charge, a constant force X cannot produce a constant current. Hence ions subject to equation (4) may be called insulating ions, and those subject to equation (3) conducting ions. Equation (3) can, however, only be regarded as applying to an average state, for strictly speaking all ions will be subjected to restoring forces, and the velocity of the conducting ions will be disturbed by impact upon the neighbouring ones.

The x component, j_x^i of the current density brought about by the displacement ξ has the value

$$j_x^i = e\mathrm{N}\frac{\partial \xi}{\partial t} \tag{5}$$

all measurement being made in electrostatic units. The total current is obtained by adding to the ionic currents the displacement current in the ether, which has the value

$$j_x^0 = \frac{1}{4\pi}\frac{\partial \mathrm{X}}{\partial t}$$

and it may then be assumed that the difference in the electrical behaviour of different bodies is solely due to differences in the qualities of the ions, but that the ions are immersed in an ether having everywhere the same properties.

The total current density in the direction OX is then

$$j_x = \frac{1}{4\pi}\frac{\partial X}{\partial t} + \Sigma e N \frac{\partial \xi}{\partial t} \qquad (8)$$

If X is constant, and $\frac{\partial \xi}{\partial t}$ is zero for zero time, we have

$$\frac{\partial \xi}{\partial t} = veX(1 - e^{-t/mv}) \qquad (9)$$

and if we put

$$mv = \theta/2\pi \qquad (10)$$

θ is the time during which a constant electric force X must operate before an ion of mass m assumes a velocity only differing from its final velocity by the $e^{2\pi}$th part, say 0·2 per cent. This time θ may be called the excitation period (*Anregungszeit*) of the ion.

For $t =$ inf., we have from (9) and (8)

$$i_x = \Sigma e^2 vN \, . \, X = \sigma' X \qquad (11)$$

where the constant

$$\sigma' = \Sigma e^2 vN \qquad (12)$$

and has obviously the meaning of the "conductivity" of the body in absolute electrostatic units.

If X and ξ are periodically variable, they must be put as proportional to $e^{i.2\pi t/\tau}$, where $i = \sqrt{-1}$ and τ is the period. Then we have by (8) and (10) for the conducting ions

$$e\frac{\partial \xi}{\partial t} = -i\frac{\tau}{2\pi}\frac{e^2 v}{1 + i\theta/\tau} \cdot \frac{\partial X}{\partial t} \qquad (14)$$

Supposing only conducting ions to be present, we have, by (8) and (14)

$$4\pi j_x = \frac{\partial X}{\partial t}\left\{1 - 2i\tau\Sigma\frac{\sigma}{1 + i\theta/\tau}\right\} \qquad (15)$$

and on putting

$$4\pi j_x = \epsilon \frac{\partial X}{\partial t} \qquad (16)$$

where ϵ can be a real or complex quantity depending upon τ, we have by Maxwell's theory the following equation for the refractive index n and the absorption κ of the body :—

$$n^2(1 - i\kappa)^2 = \epsilon \qquad (17)$$

From a combination of these equations, the author draws the following conclusions, which he verifies for 18 metals :—

(1) κ may be greater than unity. (2) When κ is < 1, then $n^2(1-\kappa)$ must also be < 1. (3) $n^2\kappa$ is always $< \tau\Sigma\sigma$, *i.e.*, $n^2\kappa < \tau\sigma'$. (4) The more $n^2\kappa$ lies below $\tau\sigma'$ in a given metal, the greater must be the excitation period θ as compared with τ in the case of some kinds of ions whose conductivity σ is a perceptible portion of the total conductivity σ', and the greater is κ in comparison with n. (5) $n\kappa$, $n^2\kappa$, and $n^2(\kappa^2-1)$ must always increase with τ. (6) Generally speaking, n increases with τ. But in metals with small n and large κ, n may decrease with τ.

The author then proceeds to determine the characteristic constants σ and θ, of the various kinds of ions from the existing records of n and $n\kappa$ and the

reflective power as lately investigated by Hagen and Rubens. In the case of the two nickel ions, the following values are obtained :—

$$\tau\sigma' = 6{\cdot}0 \qquad \tau\sigma^2 = 53$$
$$\theta_1/\tau = 0{\cdot}192 \qquad \theta_2/\tau = 16{\cdot}0$$

for yellow light.

Hence the masses of the two ions are in the ratio of 9·45 : 1, and it is most likely that the larger mass belongs to the positive ions. The latter also have the longer excitation period, but their final velocity is greater, and nearly proportional to their mass. For 1 volt per cm. the negative ions would move at a rate of 0·11 cm. per second, and the positive ions at the rate of 0·96 cm. per second, or about 200 times the rate of travel of the ions in electrolytes. The amplitude of their motion remains, however, well below the radius of molecular action, being 17×10^{-17} cm. in the negative nickel ions and $0{\cdot}6 \times 10^{-17}$ in the positive ions. The total mass of positive and negative ions contained in 1 c.c. of nickel comes out as 1·7 mg., or about 1/5,000th of the total mass. In silver, platinum, and steel it is sufficient to assume the presence of conducting ions only, while the high reflective power of gold and copper point to the conclusion that insulating ions are present as well, and that their proper oscillations lie in the infra-red region. It is also possible that some metals, such as nickel, contain other ions of much greater mass, which are optically ineffective, but considerably influence Hertzian waves. E. E. F.

1834. *Weight of Electron.* **R. v. Lieben.** (Phys. Zeitschr. 1. pp. 237–238, Feb. 24, 1900.)—The author deduces the weight of "electron" from the minute change in weight observed by Landolt (Zeit. Phys. Chem. 12. 1, 1893) in certain chemical reactions. In the reaction

$$HIO_3 + 5H_2SO_4 + 5KI = 6I + 5KHSO_4 + 3H_2O$$

the mean loss in weight was 0·077 mg. per molecule, a value which is similar to that deduced by Kaufmann from observations on kathode rays, viz., 0·53 mg. Other examples are also quoted. T. M. L.

1835. *Atmospheric Electricity.* **M. Brillouin.** (Journ. de Physique, 9. pp. 91–94, Feb., 1900.)—Cold, dry ice is very sensitive to the negative-electricity-discharging effect of ultra-violet rays, about one-tenth as much so as zinc; water is not at all so. Dry crystals of ice floating in an electric field would become charged positively and negatively, but the negative charges would escape under the influence of sunlight. The air remains an insulator, and the surrounding air becomes negatively charged. When the cirrus moves away from this air, it bears a positive charge; and if it evaporates, the air now surrounding it becomes positively charged. When the negatively charged air descends, it charges the earth negatively. At sea the negatively charged air, on expansion, forms negatively charged cumuli. At the sea-level, ultra-violet radiations have mostly been absorbed, and water is not sensible to their action; so that their direct effect is not perceptible. The effects of the travel of masses of air explain many of the phenomena of storms; and the blending of the positive and negative charges by night, when there has been no such travel, accounts for auroras, luminous clouds, and diffused illumination of the sky on summer nights in our latitudes. Variations in sun-spots cause variations in the ultra-violet radiations from the sun. The initial electrostatic field required to start the action described is produced during the displacements of the higher regions of the atmosphere with reference to the magnetised terrestrial globe. [See also Abstract No. 138 (1898).] A. D.

1836. *Lightning and Atmospheric Electricity.* **A. G. McAdie.** (U.S Weather Bureau, Bull. 26. pp. 9–44, 1899.)—This paper deals briefly, in a popular manner, with kite experiments and thunderstorm observations at Blue Hill Observatory, on Washington Monument, at San Francisco, &c., and reviews the different hypotheses on atmospheric electricity, with special regard to the views of O. Lodge on lightning and lightning conductors and protection. A few pages are devoted to auroræ. Among the illustrations are some of the author's photographs of lightning flashes. H. B.

1837. *Energy Absorbed by Condenser.* **H. Pellat** and **F. Beaulard.** (Comptes Rendus, 130. pp. 1457–1460, May 28, 1900.)—The case dealt with is that in which a condenser is subjected to a sinusoidal difference of potential. The treatment is based upon the proved existence of a real polarisation, and upon the assumption that the rate of polarisation is for any given substance solely a function of the difference $J-j$ between the actual polarisation j and the limiting polarisation J.

Let the armatures of surface s be separated by a single dielectric of uniform thickness c and of true specific inductive capacity k; at a time t, let v be the difference of potential of the armatures and j the real polarisation; let dm be the variation of the charge of the armatures during the time dt, and therefore the electric energy furnished during this time to the condenser be $dw=\mathrm{V}dm$. Then, according to the author's former work,

$$m=\mathrm{S}\sigma=\frac{\mathrm{KSV}}{4\pi c}+\mathrm{S}j$$

$$dm=\frac{\mathrm{KS}}{4\pi c}d\mathrm{V}+\mathrm{S}dj$$

and

$$dw=\frac{\mathrm{KS}}{4\pi c}\mathrm{V}d\mathrm{V}+\mathrm{SV}dj$$

If V is periodically variable, the energy w_1 absorbed per unit of volume during one period becomes

$$w_1=\frac{w}{\mathrm{S}c}=-\int_0^T jd\phi$$

where ϕ is the energy of the electric field.

The final equation arrived at is

$$w_1=\frac{2\pi^2 bh\mathrm{V}_0^2 n}{c^2(4\pi^2n^2+b^2)}$$

where n is the frequency, b is defined by the equation $\frac{dj}{dt}=b(\mathrm{J}-j)$, and h by the equation $\mathrm{J}=h\Phi$, J being the final real polarisation for the final field Φ when the difference of potential of the armatures is kept constant.

As b is a fraction of unity for good dielectrics, while $\pi\kappa n$ usually is more than 100, b^2 is quite negligible in comparison with $4\kappa^2n^2$, and the above formula becomes practically

$$w_1=\frac{bh\mathrm{V}_0^2}{2c^2n}$$

This may be further simplified by putting W_1 for the energy absorbed per unit volume and unit time, when we get

$$\mathrm{W}_1=bh\phi_0^2,$$

ϕ_0 being the effective intensity of the field. The best condenser dielectrics

for industrial purposes are therefore those for which b and h are small. With very strong fields, the energy given by the above equation is too high, and a smaller exponent would have to be substituted for 2. But this is due to the fact that h diminishes the fields of great intensity. E. E. F.

DISCHARGE AND OSCILLATIONS.

1838. *Oscillatory Discharge of Air Condenser and Determination of "v."* **O. J. Lodge** and **R. T. Glazebrook.** (Cambridge Phil. Soc., Trans. 18. pp. 136–196, April, 1900.)—The elaborate research here detailed consists essentially of the following three absolute determinations: (1) The capacity of a standard condenser which is K times a length; (2) The self-induction of a coil which is μ times a length; (3) The period of one oscillation of the electrical discharge of this condenser through the coil just named, under circumstances where the damping influences are not appreciably disturbing.

Many minor matters are discussed and corrections made where necessary, but the above three are the main quantities concerned, and are connected by the relation—

$$T = 2\pi\sqrt{\mu l_1 \cdot K l_2},$$

and this formula would be verified if the resulting value for the product of the as yet entirely unknown constants, μ and K, agreed at all closely with the already otherwise determined value, viz., the square of the reciprocal of the velocity of light. The research was undertaken with a view to affording another useful redetermination of "v," but on a closer examination of the experimental conditions, and of the departures from the above simple theory thus involved, the authors prefer to regard the work as a study of the oscillatory discharge which incidentally leads to a determination of "v" by a novel method.

After many preliminary trials the form of air-condenser finally adopted consisted of eleven flat plate-glass slabs entirely covered with tinfoil so as to resemble slabs of metal. They were each nearly 60 cm. square, and were kept about 5 mm. apart by five pieces of ebonite placed like the pips on a card. In estimating the capacity of this condenser corrections were made for the edges, for the thickness of the plates, and for the sharpness of the edges also, for the ebonite separators, and for the proximity of the floor, walls, and roof. The condenser capacity is thus found to be 5,803 cm.

The coil adopted consisted of 4,330 yards of No. 22 tinned copper wire covered with two coats of pure indiarubber and arranged in two parallel coils, each of internal diameter 10¾ inches, 4 inches deep, and 2 inches wide. These coils were arranged so that they could be used in series, in parallel, or used separately. In practice they were usually joined in simple series. The self-induction of the whole coil was determined by Maxwell's method, with great care, and found to be—

4·6362 "International Quadrants,"
or 4·6362 × $10^9\mu_0$ centimetres.

The determination of the period was made as follows: A photographic plate was whirled by a turbine at from 64 to 85 revolutions per second, and upon this plate the image, about natural size, of the spark was focused. For controlling and determining the speed of rotation a stroboscopic disc and electromagnetically-maintained Kœnig fork were used, the fork's period being known by a mechanical counter and a chronometer compared each day

with a standard clock rated from the observatory. The photographic negative was subjected to careful micrometric examination on a circular graduated plate. For one such plate the wave-length occupied an angle of 26° 11′, which corresponded to a frequency of 880 per second. The simple theory is then corrected for the electrostatic capacity of the coil, and it is found that from the above data "v" would have the value $3{\cdot}009 \times 10^{10}$ cm. per second. E. H. B.

1839. *Resistance of Sparks.* **P. Cardani.** (N. Cimento, 11. pp. 113–133, Feb., 1900; Como Congress, September 22, 1899.)—As the resistance of the circuit increases, the resistance of sparks increases. For every explosive distance the apparent resistance of the spark first rises and then falls with progressive diminution of the pressure, these variations being small for small, and greater for greater explosive distances. The maximum resistance of the spark is reached at a pressure which is lower the greater the explosive distance; and at 0·01 cm. mercury pressure, the resistance of the spark is sensibly the same for all explosive distances. A. D.

1840. *Spark at Break between Metals.* **L. Kallir.** (Ann. d. Physik, 2. 2. pp. 250–265, June, 1900.)—In an alternate-current circuit, the spark at break is characterised by a very rapid disappearance. This fact is of practical importance, inasmuch as it ensures that no metallic arcs play between the terminals of an alternate-current switchboard. This is connected with the fact that it has hitherto been found impossible to get an alternate-current arc to play between metallic terminals. The duration and intensity of the spark in question depends upon various circumstances, such as the shape of the terminals in contact, the evaporation of the material forming the spark, the speed with which the terminals are separated, and the phase of the period at which the interruption takes place. To study the effect of these elements, the author projects the spark upon a revolving sensitive plate. He employs as terminals a platinum or copper point dipping into mercury, and finds that the uncertainties connected with the elements mentioned preclude the quantitative control and prediction of the spark phenomena. But it is certain that under ordinary pressures the spark has a duration not exceeding a semi-period. Under peculiarly favourable circumstances it assumes the character of an intermittent continuous-current spark covering several half-periods. In a vacuum, on the other hand, sparking takes place in both halves of the period. This may possibly be due to the scarcity of oxygen. It appears to be immaterial whether the resistance in the circuit is inductive or non-inductive. E. E. F.

1841. *Point Discharges.* III. **E. Warburg.** (Ann. d. Physik, 2. 2. pp. 295–316, June, 1900.)—This part of the author's investigation [see further Abstracts Nos. 275 and 453 (1899)] deals with the case where the point is kept at a constant potential face to face with a plate put to earth, and the luminosity is confined to the immediate neighbourhood of the point. In this case it may be assumed that the formation of ions is confined to one sign only, which is the same as the sign of the charge imparted to the point. The arrangement should therefore be particularly effective in bringing out the differences in the properties of the two classes of ions. To determine the fall of potential away from the point, the author used a platinum probe consisting of a wire fused into a glass tube. This gave somewhat smaller values than Kelvin's water-dropping electrometer, but the differences were not great. It was

found that the fall of potential between the point and the probe, distant 0·75 mm. from it, was smaller with a negatively electrified point than with a positive point. In air the ratio was about 4 : 3 ; in hydrogen it was greater, in oxygen much less. Since in the glow discharge the fall of potential at the kathode is greater than that at the anode, it appeared interesting to study the transition from the point discharge to the glow discharge. It was found that during that transition the potential gradient underwent no marked change in the case of a negatively charged point, but that it fell to one-thirteenth of its former value in the case of a positively charged point. This indicates that the electric process changes during the transition in the latter case, but not in the former. The author supposes that in the case of a negative point the density of ions increases considerably when the glow discharge sets in, as indicated by the narrow luminous strip issuing from the point. The increased ionic density brings about an increased conductivity, and therefore also a decreased potential gradient. The author points out the remarkable influence of small impurities upon the difference of current strength, as mentioned in Abstract No. 120 (1900). E. E. F.

1842. *Influence of Incandescent Bodies on Gaseous Phosphorescence.* **K. v. Wesendonck.** (Ann. d. Physik, 2. 2. pp. 421–423, June, 1900.)—In connection with Stark's paper on this subject [see Abstract No. 642 (1900)] the author remarks that most of the effects observed could be produced with an induction coil instead of a high-potential battery, and were actually observed and described by him in 1885. The current at make does not seriously interfere if the glowing body is introduced through the side of the tube and is not connected to earth, in which case it would act as an electrode. Such a disturbing current would be indicated by the stratification of spaces otherwise dark. E. E. F.

1843. *Heat due to Kathode Rays.* **P. Villard.** (Comptes Rendus, 130. pp. 1614–1616, June 11, 1900.)—At the point where the kathode emits kathode rays a considerable amount of heat is disengaged, owing to the impact of the matter which goes to form the canal rays [see Abstract No. 1048 (1898)]. The heating of the kathode is, however, not confined to high exhaustions. The filament of a lamp can be made incandescent by means of an induction coil, if it is made into a kathode, and another filament is mounted as an anode in the same tube. The phenomenon may be produced at pressures up to one atmosphere by using metallic instead of carbon filaments. Care must be taken to have the current impulses in one direction only, and not to have the period of interruption the same as the period of elastic vibration of the filament. The difference of potential required to produce incandescence by the kathode effect is much higher than that required by the Joule effect, but the current required is much less. Tesla's incandescence phenomena are probably due to kathode heat. E. E. F.

1844. *Kathode Rays and Deviable Radium Rays.* **P. Villard.** (Comptes Rendus, 130. pp. 1010–1012, April 9, 1900.)—When kathode rays strike insulated metal there is both diffuse reflexion and an emission of kathode rays normal to the pseudo-reflecting surface. If the metal struck be very thin, there is a pseudo-refraction of kathode rays emitted by the obverse side normal to the surface. The deviable rays from radium act as kathode rays do, but the pseudo-refracted rays are accompanied by rays directly transmitted through the metal and due to the non-deviable radiations from the radium. A. D.

1845. *Production of Kathode Rays by Ultra-violet Light.* **P. Lenard.** (Ann. d. Physik, 2. 2. pp. 359-375, June, 1900; Akad. Wiss. Wien, S.ber., Oct., 1899.)—The author has made the important discovery that the impact of ultra-violet light upon a negatively charged conductor causes the latter to give out rays having all the characteristics of kathode rays. A wide vacuum tube is provided with a side tube closed by a quartz plate and a tinfoil screen, through an opening in which ultra-violet light is admitted into the tube from a zinc spark gap. The ultra-violet light impinges slantingly upon an electrode connected with an electrometer, and another electrode with a central aperture is mounted in the tube so as to face the first one. By continued heating and the working of a large induction coil the tube is brought into such a condition of evacuation that it no longer allows the discharge to pass, and the latter goes over the surface of the tube. If then the electrode is charged negatively and connected with an electroscope, the leaves of the latter collapse rapidly when the electrode is struck by ultra-violet light, and the divergence also diminishes rapidly when a condenser is inserted. Positive charges, on the other hand, remain, or decrease exceedingly slowly. With the quadrant electrometer it can be shown that the uncharged electrode assumes under the influence of the light a positive charge which can mount up to a potential of 2·1 volts. All these phenomena are annulled by placing a thin plate of mica in the path of the rays.

Measurements made by means of a large resistance show that the quantity of electricity discharged in the unit of time is practically independent of the potential of the electrode. This applies to potentials ranging from $-45{,}000$ volts to -100 volts. With smaller values the discharge is less rapid. But this is probably due to the intermittence of the source of light employed, which allows some ions to return to the electrode.

Experiments at various pressures show that the constancy of the discharge is only found in the "absolute" vacuum. Even at 0·002 mm. Hg pressure, the quantity of electricity discharged increases with the difference of potential.

The rays are propagated in straight lines, as may be shown by mounting behind the perforated electrode various auxiliary electrodes. Only those in the direct line of the radiations show a charge, and always a negative one. By means of a magnetic field the rays can be deflected so as to impinge upon the lateral electrodes. Quantitative measurements gave values for the ratio e/m of charge to mass of a particle, and of v the velocity of propagation. The ratio e/m came out as $11{\cdot}5 \times 10^6$, and v came out as $0{\cdot}12 \times 10^{10}$ cm. per second for a potential of $607 \cdot 10^8$ c.g.s. magnetic units, and 0·54 cm. per second for a potential of 12,600 units. The former speed is only one-thirtieth of the velocity of light, and these rays are therefore the slowest yet discovered. This explains why they produce no phosphorescence on the wall of the tube.

The above reasoning applies to rays in the highest vacuum attainable. It shows that the kathode rays can now be obtained without the presence of a gas and at any negative potential. When a gas is present it absorbs the kathode rays and propagates the charge by slow convection. At the same time it is rendered conducting. This explains why larger quantities of electricity are discharged in a low than in a high vacuum. It also explains the action of ultra-violet light in lowering the spark potential between metals in air when it impinges upon the negative electrode. E. E. F.

1846. *Hertz Resonators.* **A. Turpain.** (Comptes Rendus, 130. pp. 1541-1544, June 5, 1900.)—The author considers the case in which the circular wire resonators, as used by Hertz, have their plane normal to the direction of the

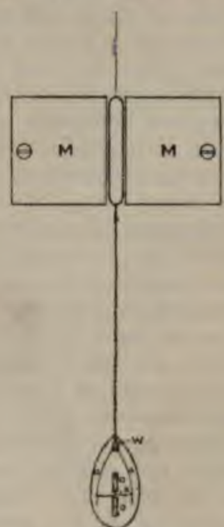
wires which concentrate the field. A resonator kept in this position shows a maximum spark-length in the micrometer gap when the ray passing through the gap is normal to the plane of the two stretched wires, and a minimum when the ray is in the plane of the wires. When the resonator contains four spark gaps on its circumference the spark gaps in the former position are active, and in the latter position inactive. This gives two nodes and two ventral segments for each resonator, a fact which is opposed to the rule that, apart from the disturbance of the gap, the length of the resonator is equal to half the wave-length of the ray which excites it. The author has therefore further examined this case by enclosing the resonator in an exhausting circular glass tube of the same size and noting the luminous phenomena attending excitation. If it is admitted that the most intense luminosity appears at the points where the variation of electric density is greatest, the aspect of the resonator agrees with a distribution such that there is a node at each extremity and a ventral segment at a point equidistant from both. E. E. F.

1847. *Absorption of Electric Waves.* **J. A. Fleming.** (Electrician, 45. p. 222, June 1, 1900.)—The author gives some preliminary results concerning the absorption of electric waves, obtained with an apparatus which produces and detects waves only a few inches in length, to be described shortly. He finds that paraffin oil, benzol, turpentine, and all insulating liquids of low dielectric constant are exceedingly transparent, but water and many liquids of high dielectric constant are very absorptive. The waves employed (about 8-inch wave-length) pass easily through a wood board an inch thick, a dozen sheets of window glass, a dozen thicknesses of dry washleather, a thick slab of ebonite, but are stopped almost completely by a couple of wet cloths, or ½-inch thickness of water, and by any substance which is very moist. Ice, on the other hand, if *dry* on the surface, is transparent to them. Constructing a large ice prism, the author has readily refracted these rays by it, and measured approximately the refractive index of ice for them. It proves to be a number near to 1·7 or 1·8. The human hand and body are very opaque to these particular electric rays, and so are some vapours. The red nitrous fumes produced by the action of nitric acid on copper appear to absorb them to some extent even if only a few inches in depth, although they will pass easily through a slab of ice some four inches in thickness. They are easily reflected from a surface of glass, and a very striking experiment may be shown by reflecting them at 45° from the palm of the hand. By splitting an electric beam into two parts and sending the two portions along two zinc tubes, which can be varied in length, the interference of two electric rays is most easily shown and the wave-length measured. Any substance which has conductivity or large dielectric constant in one direction only is very absorptive of these rays when that direction is placed parallel to the electric force of the ray falling upon it. Thus a paper of pins stops the rays when the pins are held with their length parallel to the direction of the electric force, but not when they are held normal to it. The strongly absorptive character of distilled water or alcohol shows that in these cases it is not so much conductivity as large dielectric constant which seems a determining factor. As the experiments have not proceeded very far, it is necessary to refrain from generalisation, but it appears very much as if all substances which contain in their chemical molecule either hydroxyl (HO) or nitryl (NO_2) are in the liquid, and perhaps in the gaseous, form very opaque to electric radiation, the wave-length of which is not more than a few inches. In the case of water it would seem that the absorption band known to exist in the ultra-red water

spectrum extends as far as wave-lengths 200,000 or 300,000 times as long. The electric refractive index for ice is in very fair agreement with the square root of the dielectric constant for high frequency reversals of electric force.

E. E. F.

1848. *Radio-Micrometer for Electric Waves.* **G. W. Pierce.** (Amer. Journ. Sci. 9. pp. 252–260, April, 1900.)—Klemenčič first made use of the thermo-junction for the measurement of electric waves. His device consisted of two thin sheets of brass, having soldered to them a very fine platinum and a very fine platinum-nickel wire respectively, which were crossed in the middle between the two strips, and thence conveyed off at right angles and soldered at their other ends to the leads of a very sensitive galvanometer. This resonating system was fixed at the focal line of a cylindrical reflector. Electric oscillations between the two strips produced heating at the knot, which gave rise to a current through the galvanometer. The author has combined this principle with that of Boys' radio-micrometer. The arrangement is shown in the diagram, where MM are the poles of a horseshoe



magnet. The coil consists of a single loop of silk-covered copper wire. The resonating system consists of two copper cylinders, *o o*, 8 mm. long and 1 mm. apart, which have a thin constantan and a manganin wire soldered to their ends. The resonators are sewn on to a mica vane, and the springiness of the copper leads *a a* keeps the thermo-junction in contact. To protect the latter from radiant heat, the apparatus is cased in wood.

The suspension is hung by a fine quartz fibre, of which the force of torsion serves as control. The weight of the system is 0·27 gram., of which the mirror weighs 0·05, and the resonating cylinders 0·144 gram. The period of a swing one way is three seconds. The resistance of the thermo-junction is about two ohms.

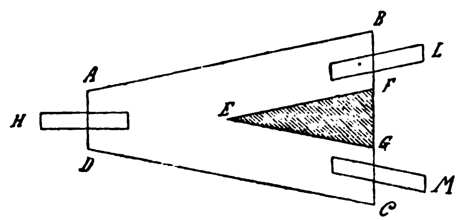
It might be supposed that the sensitiveness of the instrument could be increased by making the coil of about thirty turns, which would give it a resistance equal to that of the thermo-junction. It is found, however, that the *control* by the field, due to the magnetic properties of the copper, is so great

as to give a smaller sensitiveness with a large number of turns than with a single loop. This instrument, because of the resistance of the thermo-junction, cannot be made to have the extreme delicacy of Boys's original radio-micrometer. It has, on the other hand, a sensitiveness that is not easily obtainable by the use of a thermo-junction with a low resistance galvanometer. E. E. F.

1849. *Effect of Feelers attached to a Righi Oscillator.* **A. Lindemann.** (Ann. d. Physik, 2. 2. pp. 376–397, June, 1900.)—The author has completed a systematic study of the influence of the mast wire upon the intensity and the wave-length of the system of waves emitted by a Righi oscillator. He used a horizontal arrangement for the latter, and was thus enabled to attach auxiliary wires on both sides. He found that such an oscillator emits two superimposed wave trains, one of which has the same wave-length as that emitted by the oscillator without the wires, while the other has a greater wave-length, determined by the period of the whole oscillating system consisting of the balls of the oscillator and the wires joined by air sparks. The effect of the wires upon the original wave train of the oscillator is to strengthen it, since waves of the same length, but less damped, are emitted by the wires. The advantage of the wires increases as the air-gap separating them from the oscillator is diminished. As the air-gap increases the amplitude of oscillation of the whole system decreases in comparison with the amplitude of the original oscillation, and the damping factor increases. When one of the "feelers" was put to earth, and the other left in position, thus approximating to the arrangement used by Marconi, the second wave system could no longer be proved to exist. At least its wave-length could no longer be determined. Otherwise the phenomena were the same. E. E. F.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1850. *Hall Effect in Liquids.* **L. Amaduzzi** and **L. Leone.** (Accad. Lincei, Atti, 9. pp. 252–255, April 1, 1900.)—To decide the question whether the Hall effect is possible in liquids [see Abstracts Nos. 46 and 945 (1898)], the authors take a non-electrolytic liquid containing a substance which shows the Hall effect very strongly in the solid state. The liquid is an amalgam of bismuth. It shows the Hall effect very well, whereas pure mercury does not.



Instead of the cross used by Hall, Righi's arrangement was adopted as requiring less exact outlines. Two trapezes of plate glass were cut, A B C D (see diagram), B C being 5·1 cm. On one of them, a triangle E F G was painted with a commercial glue mixed with zinc oxide, and small plates of amalgamated copper were laid on at H, L, and M. The second glass was then put on top, and all the edges glued round with the same glue except A D The trapeze was then exhausted and A D plunged into a 15 per cent. bismuth

amalgam which entered on readmitting the air and filled up all the space except the triangle E F G. A D was then also closed, and the trapeze then contained a layer of amalgam 0·02 mm. thick, bifurcated at B C. A current was sent from H through the two branches, and the two divisions of the current were balanced against each other.

The trapeze was exposed to a strong and uniform magnetic field, and it was then found that one branch of the current was increased at the expense of the other. On reversing the magnet, the balance of the two branch currents was also reversed, but the differences were not the same, owing to a difference of resistance produced by magnetisation, as in the case of solid bismuth. No such effects could be produced in pure mercury under the same circumstances. The results are not exact enough to give quantitative measurements, but they show at all events that the Hall effect is not inconsistent with the liquid state. E. E. F.

1851. *Break-Current in a Branch Circuit.* **K. R. Johnson.** (Ann. d. Physik, 2. 3. pp. 495–504, July, 1900.)—The author gives a mathematical treatment of the course of the current and potential in a broken circuit containing a branched portion. He shows that Edlund's theoretical views and experimental results are confirmed and explained. The spark at break may be eliminated by introducing a third branch free of inductance. [See also Abstracts Nos. 1302 and 1673 (1900).] E. E. F.

1852. *Thermo-electricity.* **C. Liebenow.** (Elektrotechn. Zeitschr. 21. pp. 246–249, March 22, 1900.)—General discussion of the history of thermo-electricity. Theory suggested that the E.M.F. in the circuit is a differential effect, the difference between two E.M.F.'s, each in its own unequally heated metal. F. Kohlrausch has already suggested this. If the smaller E.M.F. increase more rapidly than the larger under increase of temperature, we have the difference diminishing and ultimately a reversal of direction of the thermo-electric current. [For the mathematics of the subject see Verh. d. Deutsch. Phys. Ges., Bd. I. pp. 74 and 82, 1899, Abstract No. 1515 (1899); and Wied. Ann. 68. p. 316, 1899, Abstract No. 1516 (1899).] If R is the electric resistance of the metal in ohms, L the heat conductivity in gramme-calories per second, and τ the absolute temperature of the warmer end of a bar of the metal, then the E.M.F. in volts between the two ends when these two ends differ in temperature by 1° C is

$$e = \pm 2{\cdot}04 \sqrt{\mathrm{RL}/\tau}.$$

If we measure L in electric units instead of gramme-calories, the factor 2·04 is omitted; and the $\pm$ sign shows that theory indicates nothing as to the direction of the E.M.F. The heat-conductivities of the metals are imperfectly known; but the values in Wüllner's table (Lehrb. d. Exp.-Physik, 5th. Ed. Vol. 3. p. 641) lead to e being 137½ microvolts in copper and 128 in iron. The difference between these is 9½ microvolts, as against 10 to 13 microvolts in the observed thermoelectric E.M.F. The electric resistance of iron increases more rapidly than that of copper; and the difference should disappear at 250° C., as against 270° C., the temperature of reversal. With most metals the results are concordant. Further, it appears that in all metals the hotter end is positive; in non-metals it is negative. If we combine a metal with a non-metal to form a thermoelectric couple, we ought to be able to make some use of the sum and not the difference of the two E.M.F.'s. If we could find a metal and an alloy in both of which the electric and the thermal con-

ductivities had the same ratio to one another, the full sum would be available; and with junctions at 1000° C and ordinary room-temperature, about 77 per cent. of the heat supplied to the hot junction would be in the first place converted into energy of current. About half this would, however, be lost in Joule effects, and the other half, say 38 per cent., would be available for the total circuit, but half of this would again be lost in Joule effects, leaving 19, or say 15, per cent. efficiency. This rate of efficiency would be most valuable, but the proper conducting materials are still to seek, so that the two E.M.F.'s may be opposed and as nearly as possible equal. A. D.

1853. *Effects of Strain on Thermo-electric Qualities.* **M. Maclean.** (Roy. Soc., Proc. 66. pp. 165–178, April, 1900.)—In a previous paper [see Abstract No. 1177 (1899)] an account was given by the author of his attempts to determine the magnitude of the thermo-electric effects obtained from any one metal strained and unstrained. A description of the continuation of similar experiments is given in this paper, the metals used being commercial and pure lead, annealed steel, aluminium and nickel. The method employed was to take a piece of the wire and draw it through a few holes of a draw-plate, so as to reduce its cross sectional area to about a quarter. The two pieces of wire, one drawn and one undrawn, were then joined, and observations were made on the currents obtained as the difference of temperature of the junctions was raised by successive steps to 100° C. The current in micro-amperes per degree up to 100° C being known and the resistance of the conductors measured, the thermoelectric difference per degree between drawn and undrawn wires is found. The results obtained were as follows :—

Steel, annealed	0·1028
Aluminium	0·0099
Nickel	0·3784
Lead, commercial	0·026
Lead, pure	0·0076

The numbers express the thermo-electric differences in micro-volts per degree C. diff. of temp. In the case of steel the values obtained were :—

1. Glass-hard steel 2. Unannealed steel	7·5	micro-volts per deg. C.
1. Unannealed steel 2. Annealed steel	0·18	„ „
1. Glass-hard steel 2. Annealed steel	7·67	„ „

Experiments were also made to determine the thermo-electric difference between free wires and wires previously permanently elongated by a longitudinal stress. The results are given in a table and include various kinds of copper, and reostene, platinoid, German silver, manganin, aluminium and nickel. Further experiments are next described on the thermoelectric differences between free wires and wires while (*a*) under stress within their limits of elasticity, and (*b*) under stress, stretching them beyond their limits of elasticity. It appears (1) that for small longitudinal strain in copper or in iron the direction of the current through the hot junction is the same, whether the force which produced the permanent strain is on or off; (2) that as the permanent elongation is increased, a stage is reached which gives zero

current when the forces are removed; and (3) that for greater longitudinal forces and permanent elongations the direction of the current is opposite, with the pulling forces off and on. Probably the permanent elongation must exceed a definite limit, to produce reverse thermo-electric effects with the longitudinal force on and removed.

The percentage elongations in the various cases, together with the thermo-electric differences in micro-volts per degree, are given in a set of tables.

J. J. S.

1854. *Conductivity of Gases from an Arc and from Incandescent Metals.* **J. A. McClelland.** (Cambridge Phil. Soc., Proc. 10. pp. 241–257, Jan., 1900.)—The first part of this paper contains an account of experiments on the conductivity of gas through which an arc discharge has passed; the second part refers to somewhat similar experiments on gas taken from the neighbourhood of an incandescent wire. In both cases the gas has considerable conductivity which can be shown to be due to ionisation, or a production in the gas of positively and negatively charged carriers of electricity. Experiments were made with the arc and with the incandescent wire in air, oxygen, and carbonic acid gas; the relation between current and E.M.F., the recombination of the carriers, the velocity of the carriers under electric force, and other points were investigated.

The conductivity of the gas was measured by observing the rate of leakage across it as indicated on a quadrant electrometer. As the E.M.F. increased the current across the gas, which at first was proportional to the E.M.F., approached a maximum value. The effects can be accounted for by supposing the discharge to take place by means of carriers of electricity. The velocity of the carriers varied greatly with the nature of the arc. In CO_2, as in air and oxygen, the velocity of the negative carrier is greater than that of the positive, the excess being about 25 per cent. in oxygen and 40 per cent. in CO_2.

Similar results were obtained when an incandescent wire was used to produce ionisation and render the gas conducting. J. J. S.

1855. *Electric Relations of Flame.* **P. Villard.** (Soc. Franç. Phys., Bull. 146. pp. 2–3, 1900.)—The gases of flame and the air which surrounds flame within from 2 to 3 decimetres are equalisers of potential when the flame is produced within an electric field and not otherwise, contrary to the received opinion. Various phenomena may be co-ordinated by supposing that flames, incandescent bodies and phosphorus, placed within an electric field, all emit kathode rays; and the bodies most readily discharged by the ultra-violet light are those which are most ready emitters of kathode rays in a vacuum tube. The formation of ozone would thus appear to be a direct consequence of the kathode radiation. The emission of kathode rays is accompanied by heating, which may even go on to incandescence; and that not merely in Crooke's tubes, but at higher pressures. A. D.

1856. *Influence of Proximity of Mass upon Electric Conductivity.* **G. Gore.** (Phil. Mag. 49. pp. 558–559, June, 1900.)—The proximity of a mass of lead weighing about 80 pounds was found not to have any perceptible influence on the resistance of a coil of copper or aluminium wire. T. M. L.

1857. *Hysteresis of Resistance.* **H. Chevallier.** (Comptes Rendus, 130. pp. 1612–1614, June 11, 1900.)—The author continues his previous work on

the influence of tempering upon the resistance of an alloy of platinum and silver [see Abstract No. 862 (1900)]. When the wire is subjected to a certain number of "disturbances" at the temperature T_2, alternating with a series of oscillations between two lower temperatures, T_0 and T_1, which are always the same, its resistance at T_0 tends towards a value which is called the "limit of limits" with respect to the temperature T_2. The value undergoes great variations when T_2 is as high as a bright red, and these variations obey different laws according to the temper of the wire. The temperature curve of these variations has the same general form both for a tempered and an annealed wire, with a maximum at about 325° and a minimum at about 470°. Neither of them is reversible, the returning line not coinciding with the outward line, but running below the former between 320° and 460°, and above it at temperatures below 320°. At temperatures between 460° and 700° the wire shows the least amount of this kind of hysteresis. E. E. F.

1858. *Compensation Resistance.* **T. Bruger.** (Phys. Zeitschr. 1. pp. 167–168, Jan. 6, 1900.)—The resistance-box described is intended to be direct-reading, and at the same time to work with switches instead of plugs, while keeping the total resistance constant. The total resistance of

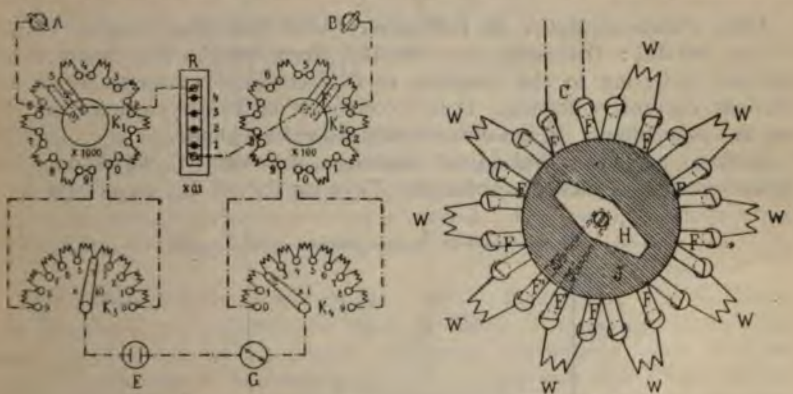


Fig. 1. Fig. 2.

10,000 ohms is distributed over four switch rheostats, K, with the addition of a plug-box, R, for fractions of an ohm (Fig. 1). The construction of K_1 and K_2 is shown in Fig. 2, where F F F are double springs forming a metallic connection between successive coils, except F′F′, which are joined by the springs attached to the switch H. E. E. F.

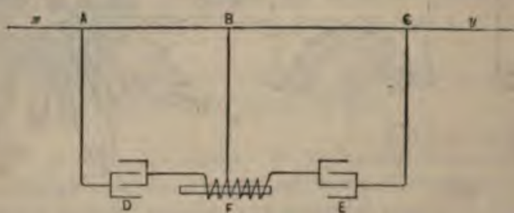
1859. *Simultaneous Testing for Fault Localisation.* **C. W. Schaefer.** (Electrician, 45. pp. 253–255, June 8, 1900.)—A description of practical examples of localisation of faults in cables by milliammeter readings taken simultaneously on board ship and ashore, the battery being applied at one end, and the conductor resistance being known, or ascertained at the time of test while the fault is sealed. The method is shown to be of value, especially with a variable earth fault, which, in the case quoted, changed from 700 ohms to 2·5 megohms. At the higher limit the opportunity was taken to measure the copper resistance, the true value of which of course is required for working out the results from the milliammeter readings at both ends. This is done by ordinary equations for derived circuits. In one instance

cited the position of the fault was localised within 100 ohms. of the actual spot, and in another within 12 ohms. The earth current is to be observed before testing, and allowed for unless very small, and the data required for calculation obtained from say half a dozen readings taken every fifteen or thirty seconds by prearrangement. In one case, where the fault was very variable, and caused by a piece of foreign matter in the guttapercha, the author thinks that no other method of localisation would have so well answered his purpose. E. O. W.

1860. *Kohlrausch Bridge Resistances.* **R. Abegg.** (Phys. Zeitschr. 1. p. 179, Jan. 13, 1900.)—Instead of adding equal resistances on each side of Kohlrausch's coiled bridge wire, the author adds a resistance of eight times the value of the bridge wire on one side, and a resistance equal to that of the bridge wire on the other side. In the arrangement VIII—I—Br, or Br—VIII—I, the first and last tenths of the bridge wire (Br) are increased in sensitiveness ten times, whereas, when the bridge wire is in the middle, the second and ninth tenths are similarly increased in sensitiveness. This is for most purposes more important than it is to increase the sensitiveness of the middle region. E. E. F.

1861. *A Capacity Meter.* **M. I. Pupin.** (Amer. Inst. Elect. Engin., Trans. 17. pp. 189–191; Discussion, pp. 192–197, April, 1900.)—The theory is as follows: Referring to the diagram, xy is a conductor through which an alternate current is flowing. D is a condenser of known capacity, and E one that is unknown. F is a differentially wound telephone.

Connect as shown, and adjust resistances A B and B C, which must be inductionless until silence is obtained. Then capacity of D : capacity of E : :



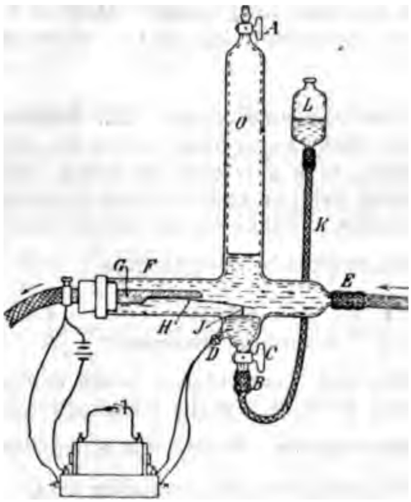
resistance of B C : resistance of A B. In place of a differential telephone an ordinary one can be put in the bridge B F.

A description of the apparatus is given, the alternating current being obtained from the secondary of a small induction coil provided with an interrupter such as is used in electrotherapy.

[This method was practically described in a paper by the abstractor read before the Physical Society, June 25, 1887, entitled, "Note on Comparing Capacities."] E. C. R.

1862. *Mercury Interrupter.* **E. Grimsehl.** (Elektrotechn. Zeitschr. 21. pp. 491–492, June 14, 1900.)—The author has designed a mercury interrupter on a novel and ingenious principle; he claims that it absorbs little energy and mercury, costs little, and is efficient on circuits provided with a low supply of power. The interruptions are produced by the reed of an organ pipe "blown" by a current of water, which serves the additional purpose of *keeping* the mercury clean and cool. The construction is shown in the

diagram, where G is the organ pipe, H the reed, J a platinum tip attached to it, O a cushion of air which serves to impart the necessary elasticity to the water, and E the tube through which the water flows in. The level of the mercury is regulated by the tap C and the reservoir L, connected to it by the flexible tube K. Interruption is very abrupt, owing to the high resistance of



the water, and the rate of interruption is of course much steadier than in the Wehnelt interrupter, but on the other hand it cannot be brought much higher than 100 per second. Any mercury carried off by the water can be collected in a wash bottle inserted in the water current. The platinum point shows very little wear, owing to the cooling effect of the water. E. E. F.

1863. *Wehnelt Interrupter Circuits.* **G. T. Hanchett.** (Elect. World and Engineer, 35. pp. 663–665, May 5, 1900.)—The author studies the indications of commercial electric measuring instruments when used on circuits containing a Wehnelt interrupter. The fact that direct-current instruments in the primary circuit give large deflections shows that the main current value predominates on one side of the zero line. The current wave is full of jagged peaks with greater rate of change on the decrease than on the increase. The formidable and unidirectional secondary discharge could not be otherwise accounted for. The voltage of supply can be measured with reasonable accuracy by any suitable commercial instrument. An indicating wattmeter of the dynamometer type will give approximate results on the various parts of the Wehnelt circuit. A calorimetric test of the interrupter will greatly assist in verifying this possibility. The inductive portions of the circuit generate a back electromotive force of self-induction, which, combined with the impressed electromotive force, produce a resultant often much larger than the total line voltage and undoubtedly lagging behind the pulsating impressed electromotive force. The electromotive force wave around the inductive resistance is filled with peaks of instantaneous maxima exceedingly steep and abrupt and nearly evenly divided on either side of the zero line. Around the interrupter is generated an electromotive force which combines with the impressed electromotive force, producing a resultant often very much larger than the line potential, and leading the impressed pulsating

electromotive force. Direct-current instruments may possibly be relied on to measure the total voltage of the Wehnelt circuit and the current flowing therein. They take no heed whatever of any alternating resultants due to self-induction or capacity or similar effect, but approximately follow Ohm's law throughout the circuit. The alternating-current dynamometer voltmeter does take account of the alternating resultants around various portions of the circuit and gives an approximate idea at least of the square root of the mean square value. E. E. F.

1864. *Damping of Galvanometer Needles.* **M. Solomon.** (Phil. Mag. 49. pp. 559–570, June 1900. Paper read before the Physical Society of London.)—In the motion of a galvanometer needle under the retarding forces of the controlling field, of eddy currents in neighbouring metallic masses, and of air friction, the time for the reduction of the deflection to $1/m$ of its original value, is given by $\tau = 1/2 \log_e m \frac{t}{\lambda}$,

where— $\frac{t}{\lambda}$, or $\frac{\text{period}}{\text{logarithmic decrement}}, = 4\frac{I}{N}$

(I = moment of inertia, and N = resistance to the motion of the needle), provided the assumption be made that the retarding forces are proportional to the first power of the velocity. Making this assumption, therefore, $\frac{t}{\lambda}$ and τ are independent of the strength of the controlling field.

The author has made experiments on various galvanometers to determine whether this result is borne out in practice. He varied the strength of the controlling field, measuring this by the period of the galvanometer, and gives tables showing the variation of the ratio t/λ with the period. In every case the ratio was found to increase with the period. Experiments were then made with a galvanometer free from any masses of metal which could be the seat of eddy-currents. With the circuit of the galvanometer coils open the ratio t/λ was constant for periods of from 2·5 to 17·5 seconds; when eddy-current damping was introduced by short circuiting the coils, the ratio increased by about 9 per cent. for the same variation of period.

As the damping effect of eddy-currents is proportional to the square of the needle strength, the author concludes that the increase of the ratio with increasing period, *i.e.*, with decreasing strength of controlling field, is due to variations in the strength of the needle consequent on variations in the controlling field. G. H. B.

1865. *Use of Braun's Kathode Ray Tube for Alternate-current Curves.* **H. J. Oosting.** (Phys. Zeitschr. 1. pp. 177–179, Jan. 13, 1900.)—When alternate-current curves are traced by means of the Braun tube [see Abstract No. 1,095 (1900)], a difficulty is presented by the intermittent character of the kathode rays, and another by the necessity of securing synchronism between the alternator furnishing the current and the revolving mirror. These difficulties have been overcome by the author by the expedient of mounting the sensitive curve paper direct on the shaft of the alternator, thus dispensing with the mirror altogether, and securing perfect synchronism between the revolution of the curve paper and the deflection of the kathode beam. The deflections must of course be parallel to the axis of the shaft. The successive curves are then superimposed upon each other, and both the discontinuity and the photographic feebleness of the kathode

rays are met. If several successive alternations are to be obtained in one revolution, the recording paper or film can be mounted on an auxiliary shaft driven by the first through some suitable gear. The exposure depends upon the strength of the rays, the velocity and diameter of the shaft, and the tracing medium used. With a Wimshurst machine to generate the rays, the author obtained a good record on bromide paper in five minutes, and on an Eastman film in one minute. E. E. F.

ALTERNATING CURRENTS AND MAGNETISM.

1866. *Expression of Power in Alternating Current Circuits.* **H. Sire de Vilar.** (Écl. Électr. 23. pp. 246–252, May 19, 1900.)—A simple harmonic function can always be transformed into an exponential function thus—

$$\cos x = \frac{1}{2}\left(e^{ix} + e^{-ix}\right), \text{ where } i = \sqrt{-1}.$$

The harmonic function—

$$y = A \cos(\omega t + \phi)$$

can be written—

$$y = \frac{A}{2}\left\{e^{i\omega t + i\phi} + e^{-i\omega t - i\phi}\right\}$$

$$= \frac{A}{2}\left\{e^{i\phi} e^{i\omega t} + e^{-i\phi} e^{-i\omega t}\right\}$$

Now consider two harmonic functions—

$$y_1 = \frac{A_1}{2} e^{i\phi_1} e^{i\omega t} + \frac{A_1}{2} e^{-i\phi_1} e^{-i\omega t}$$

$$y_2 = \frac{A_2}{2} e^{i\phi_2} e^{i\omega t} + \frac{A_2}{2} e^{-i\phi_2} e^{-i\omega t}$$

Their product is—

$$y_1 y_2 = \frac{A_1 A_2}{4} e^{i(\phi_1 + \phi_2)} e^{2i\omega t} + \frac{A_1 A_2}{4} e^{-i(\phi_1 + \phi_2)} e^{-2i\omega t}$$

$$+ \frac{A_1 A_2}{4} e^{i(\phi_1 - \phi_2)} + \frac{A_1 A_2}{4} e^{-i(\phi_1 - \phi_2)}$$

The same result is arrived at by decomposing into its vector constituents each of the real terms of the product $y_1 y_2$.

We see that $y_1 y_2$ is half the sum of two imaginary conjugates.

Here we agree to take one of these vectors to represent $y_1 y_2$ and put—

$$(y_1 y_2) = \frac{A_1 A_2}{2} e^{i(\phi_1 + \phi_2)} e^{2i\omega t} + \frac{A_1 A_2}{2} e^{i(\phi_1 - \phi_2)}$$

If from the instantaneous products we pass to the mean products over a period, we get—

$$\frac{1}{T}\int_0^T (y_1 y_2) dt = \frac{A_1 A_2}{2} e^{i(\phi_1 - \phi_2)}$$

If in place of the amplitudes we consider the virtual values, we get—

$$\frac{1}{T}\int_0^T (y_1 y_2) dt = A_1 A_2 e^{i(\phi_1 - \phi_2)}$$

We thus obtain the imaginary expression of the power already found by Steinmetz.

$$\frac{1}{T}\int_0^T (y_1 y_2)dt = A_1A_2\left\{\cos(\phi_1 - \phi_2) + i\sin(\phi_1 - \phi_2)\right\}$$

The first term—

$$A_1A_2\cos(\phi_1 - \phi_2)$$

is the real power, and the term—

$$A_1A_2\sin(\phi_1 - \phi_2)$$

is the wattless power.

We note that if in the product y_1y_2 we had neglected the second imaginary instead of the first, we should have represented y_1y_2 by—

$$(y_1y_2) = \frac{A_1A_2}{2}e^{-i(\phi_1 + \phi_2)} + \frac{A_1A_2}{2}e^{-i(\phi_1 - \phi_2)}$$

and the integral would then be—

$$\frac{1}{T}\int_0^T (y_1y_2)dt = \frac{A^1A_1}{2}e^{-i(\phi_1 - \phi_2)}$$

$$= \frac{A_1A_2}{2}\left\{\cos(\phi_1 - \phi_2) - i\sin(\phi^1 - \phi_2)\right\}$$

In the other terms the real power remains the same and the wattless power changes in sign. W. G. R.

1867. *Permanent Magnets and Temperature Coefficients.* **I. Klemenčič.** (Akad. Wiss. Wien, S.ber. 108. pp. 491–510, and 989–1000, 1899.)—Eighteen pieces of steel of square section were magnetised in a uniform field of 8·65 units and their temperature coefficients (β) were measured by means of a magnetometer and compensating coil. The temperatures ranged from 2° to 35° and the specific resistance (σ) was measured at the ends and middle in order to judge the hardening. It is shown that β is inversely proportional to the quantity, length / breadth (l/b). The results obtained for one specimen 4 mm. broad are given in the following table :—

l nearly.	β	Mean temp.	l/b	$\beta \times l/b \times 10^4$
cm.				
4	0·000437	19·5	9·9	42·2
6	301	19·5	15·2	46·5
8	213	19·8	20·6	43·7
10	176	19·7	25·4	44·8
15	135	20·8	37·7	51·8

The induction coefficients were determined, in various fields and for magnetic and unmagnetic conditions, of the same steel bars as were used in the determination of the temperature coefficients. If μ and μ_0 represent the changes in magnetic moment per gramme per unit field in magnetised and unmagnetised conditions respectively, μ_0 is found to be greater than μ when the dimension-ratio of the magnet (length/breadth) varies between 40 and 15, and for dimension-ratios between 15 and 5, μ and μ_0 are practically equal. So

far as the experiments go, these coefficients do not change with the field strength, but vary in the same sense as the dimension-ratio. A series of experiments (on magnetisation) in which the same bars were tested, first, by withdrawing the magnetising force suddenly, and, second, by reducing it gradually to zero, shows that, except when the dimension-ratio is very small, there is very little to be gained by magnetising by the second method. The increase obtained by the second method is more marked when the sectional area is large. G. E. A.

1868. *Condenser Currents in Symmetrical Polyphase Systems and their Graphical Representation.* **C. E. Guye.** (Écl. Électr. 23. pp. 408–415, June 16, 1900.)—The author states that the high voltages now used in power transmission schemes make the problem of the condenser currents in a polyphase system one of great importance. He shows how to calculate the condenser currents in the case when we have two, three, or four conductors symmetrically placed inside a hollow cylindrical conducting sheath, when everything is symmetrical and the E.M.F.'s follow the harmonic law. In the case of a three-phase system, for example, we can calculate the condenser currents on the supposition that we have a condenser of capacity K connecting each main to the sheathing [see 1900, Abstract No. 1308]. The calculation of K presents very great difficulty, but it can easily be determined practically as follows. First measure the capacity (K_1) between the three conductors in parallel and the outer sheathing in the ordinary way by a ballistic galvanometer and a standard condenser. Next measure the capacity (K_2) between one of the conductors and the other two joined to the sheathing. Then the author proves that—

$$K = \frac{9\,K_2 - K_1}{6}$$

The following data concerning three three-phase high tension conductors are given by M. Revillod, of the Berthoud Borel Cable Company at Lyons:—

	1st cable.	2nd cable.	3rd cable.
Working pressure in volts	10,000	10,000	20,000
Section of conductor in sq. mms.	85	140	50
Diameter of conductor in mms.	13·1	16·65	13·85
Length of cable in kilometres	5 (about)	11	0·1
Minimum distance between conductor and sheathing in mms.	9	9	18
Minimum distance between two conductors in mms.	10·5	10·5	18
Capacity per kilometre between three conductors in parallel and sheathing (K_1) in microfarads	0·282	0·314	0·204
Capacity per kilometre between one conductor and the other two and the sheathing in parallel (K_2)	0·143	0·166	0·095

The values of K calculated for the three cables are given as 0·1675, 0·1967 and 0·108 respectively. These values are all about 13 per cent. greater than K_2. A. R.

1869. *Permanent Magnets.* **H. Frank.** (Ann. d. Physik, 2. 2. pp. 338–358, June, 1900.)—A number of magnets were prepared of the same piece of

English silver steel. They were chilled from several high temperatures ranging from a dull red to a white heat, and then magnetised by the same current and coil. The highest magnetic moments were shown by those magnets which had been chilled from a normal red heat, midway between the dull red and the white. The influence of the temperature is very considerable. Thus the moment obtained after heating to normal red is double that obtained after heating to dull red, and 30 per cent. higher than that obtained after heating to a white heat. The duration of the heating, however, seems to have no influence whatever. The temperature at which the magnetisation itself is carried out is also of importance. If carried out at a low temperature, the moment obtained is higher than if the magnetisation takes place at, say, 100°. But the difference is very slight when the steel has been chilled from a bright red or a white heat. The "loose magnetism" is more easily got rid of when the chilling takes place from a low heat than from a high one, and Barus and Strouhal's methods of ageing magnets either by boiling or by cycles of temperature appear to be the best all round. E. E. F.

1870. *Atomic Magnetism.* **R. Lang.** (Ann. d. Physik, 2. 3. pp. 483–494, July, 1900.)—The author interprets the amperian molecular currents as convection currents produced by the revolution of negative electrons as satellites round the heavier positive electrons. On the supposition that the periodic time of such an electron cannot be the same as the vibration period of visible light without giving rise to luminous effects, he arrives at a period which is more rapid than that of ultra-violet light, and leads to no contradictions. The periodic time is about 10^{-19} sec., the diameter of the orbit about 10^{-9} cm., and the magnetic moment of a divalent iron atom comes out as $8{\cdot}6 \times 10^{-20}$ c.g.s. units. This would give for the saturation moment of a cubic cm. of normal $FeSO_4$ solution the value of 4·6 c.g.s. units. This agrees so closely with Jäger and Meyer's experimental value of 1·6 units that the attempt to bring theory and experiment into harmony along the lines indicated is permissible. Since the same value applies to the solutions of cobalt, nickel, and manganese sulphates, and yet the atomic susceptibilities of nickel, cobalt, iron, and manganese are as 2:4:5:6, the author suggests that this diversity may be due to differences in the number of free valencies, such as are suggested by the different number found to occur in each. If the free valencies alone have a determining influence upon molecular magnetic susceptibilities, then chemical combination may very conceivably exert an influence upon the magnetic properties of a substance. This would explain why the oxides of some paramagnetic metals are diamagnetic.

It is not necessary to assume that the negative satellites are always associated with the same positive electron. If their velocity becomes very great they may fly off and revolve round another positive electron. Their usual velocity is that of light. Ordinarily, the projection of an electron beyond the surface into a surrounding dielectric produces a strong difference of potential which hinders further losses. But if the surrounding medium is a dielectric, and the difference of potential is equalised as soon as established, a continuous current may be set up. This takes place in Hurmuzescu's experiment, in which two iron wires are immersed as electrodes in a solution of acetic or oxalic acid, and one of them is magnetised. It appears that when the magnetic field is such that the lines of force do not leave the surface vertically, negative electrons are shot off into the liquid, owing to the plane of their orbits being inclined to the surface of the iron. E. E. F.

MEDICAL ELECTRICITY.

1871. *The Radiogoniometer.* **Guilleminot.** (Archives d'Él. Médicale, 8. pp. 158–170, April, 1900.)—The angle at which the Röntgen rays strike the part to be photographed can be determined by the instrument named above, and secondarily the position of the tube can be adjusted by its use so as to bring the tube into the most favourable position. The principle of the instrument is that of a fixed wire cross and a movable one; the latter is so adjusted that the shadows of both upon a fluorescent screen coincide, and the angle is then read off by means of divided arcs of circles. By a sighting arrangement, or by a rigid metal rod, the line of incidence can be found and marked upon the surface of the subject's body. The author's couch is a double decked arrangement, the tube being fixed to the roof. Two figures are given. H. L. J.

1872. *Complete Electrotonus.* **Mlle. I. Ioteyko.** (Archives d'Él. Médicale, 8. pp. 149–152, April, 1900.)—An article describing experiments upon the production of electrotonus in the exposed sciatic nerve of the frog. When a current of 0·0002 ampere is caused to traverse a short length of the nerve, a state of anelectrotonus is set up round the position of the anode and produces at that point a complete block to the transmission of impulses along the nerve. H. L. J.

1873. *Electro-Therapeutics.* **H. L. Jones.** (Inst. Elect. Engin., Journ. 29. pp. 346–366; Discussion, pp. 366–381, April, 1900.)—The author gives a short account of the elements of electro-therapeutics. He describes the manner in which muscles and nerves respond to electrical stimulation, and proceeds to explain, as well as is possible to a non-medical audience, some of the principles of electro-diagnosis. Coming next to the question of treatment, he states that progress moves along in two lines—one of these is based on experimental physiology, the other is by direct experiment in a more or less haphazard manner on the sick. He then defines the limits in which electricity is useful in paralysis and the relief of pain; and refers to the cataphoric introduction of drugs, as well as to the usefulness of electrolysis in minor surgery. Electrodes, batteries, &c., are then discussed, and lastly Röntgen ray work, as developed by medical practitioners, is briefly touched upon. W. S. H.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1874. *Distillation of Amalgams and Purification of Mercury.* **G. A. Hulett.** (Zeitschr. Phys. Chem. 33. pp. 611–621, June 1, 1900.)—The presence of 1 part of zinc in 10^{-9} parts of mercury can be detected by adding the amalgam to pure mercury in the combination Hg/HgO in aqueous CO_2/Zn, the E.M.F. being immediately lowered if any trace of zinc is present.

V. Meyer has stated that mercury requires twelve distillations in order to free it from metallic impurities; this is due to the fact that the boiling usually takes place with considerable bumping. If, however, the distillation is carried out in a mercury-vacuum or in a current of an indifferent gas, the mercury evaporates quietly, and a complete purification can be effected in one distillation, using merely two Wurtz flashes as boiling-flash and receiver. If zinc oxide is present with the amalgam it is carried over mechanically in the form of dust, but no metallic zinc is present in the distilled mercury, which merely requires filtering to free it from all traces of zinc. Using a water-pump to exhaust the receiver, the mercury boils at 210°, and since no zinc can be detected in the distillate, the vapour pressure of zinc at this temperature must be less than $\frac{1}{5} \times 10^{-7}$ of that of mercury at the same temperature. T. M. L.

1875. *Vapour-density of Bromine at High Temperatures.* **E. P. Perman** and **G. A. S. Atkinson.** (Zeitschr. Phys. Chem. 33. pp. 577–578, June 1, 1900.)—C. Langer and V. Meyer have determined the vapour density of bromine-vapour at 900° when diluted with eleven times its volume of nitrogen; the value obtained was 5·459 (air = 1) or 78·88 (hydrogen = 1), and compares closely with that given by the authors [see 1900, Abstract No. 1518] for pressures between 365 and 767 mm. This confirms the conclusion that the degree of dissociation is, at this temperature, only slightly influenced by the pressure. T. M. L.

1876. *Liquid Crystals.* **O. Lehmann.** (Deutsch. Phys. Gesell., Verh. 2. 6. pp. 72–76, 1900.)—The only definition of a crystal to which no objection can be taken is one based on the fact that, during crystal growth, the new layers deposited are regularly orientated with regard to the particular type of anisotropy present in the crystal. This regular deposition may be considered as due to a certain molecular force to which the author gives the name "molecular directing-force (*Richtkraft*)," and which is not identical with elasticity, as is evident from a study of azoxyanisol and azoxyphenetol, which form liquid crystals having no elasticity. The molecules in these crystal drops strive to arrange themselves parallel to the surface; the anisotropy of the molecules corresponds to the monosymmetric system, and it must be assumed that, in the interior of the crystal drops, the molecules are arranged on concentric spherical surfaces around a common axis of symmetry. With a drop resting on a flat surface the latter is perpendicular to the axis, whilst if the drop be pressed between two flat plates the axis lies parallel to the pressing surfaces. In the direction of the axis a crystal drop has the appearance of a point-like nucleus surrounded by a circular halo, and perpendicular to the axis it looks as though the drop contained a lens standing on its edge. [In] polarised light the drops show a colourless-yellow dichroism, and between

crossed nicols whose principal directions of vibration coincide with those of the molecules, they appear dark or more frequently coloured, since for one particular colour there is usually circular polarisation due to the superposition of differently orientated molecules. In the magnetic field (strength 3,000–8,000) the axis endeavours to place itself parallel to the lines of force, but complete compensation of the molecular directing force by the magnetic force could not be obtained with the strengths of field used. If two liquid drops flow together, a drop is first formed having two round nuclei and a four-angled convergence-point corresponding to the centre of the system of lemniscates, which then determines the arrangement of the molecules; two drops may also be arranged concentrically. By the aggregation of several drops with axes perpendicular to the flat supporting surfaces, the number of convergence-points is always one less than that of the points of symmetry. If, however, several drops are pressed between two surfaces—their axes being hence parallel to these surfaces—when they flow together their poles show a tendency to approach one another and join.

Since all possible intermediate forms between crystal drops and solid crystals are conceivable, the term "solid" must be omitted from the definition of a crystal. Liquid crystals can be arranged in the various crystalline systems, and although in general they do not possess a polyhedral shape owing to surface-tension effects, yet these latter can be removed, and liquid crystals with molecules arranged in parallel rows obtained. T. H. P.

1877. *Reciprocal Action and Equilibrium between Trigonal Pole-systems: Theory of Crystal Structure.* **E. Riecke.** (Phys. Zeitschr. 1. pp. 277–282, March 24, 1900.)—The author considers an electric pole-system consisting of a regular hexahedron at the angles of which are alternately positive and negative poles of equal strength. From such trigonal pole-systems molecule-lattices can be constructed, having the symmetry corresponding to the sphenoidal-hemihedral division of the hexagonal system, and to a certain extent to that of trapezohedral group of the same system. The action between the pole-systems and the conditions of equilibrium of the lattices are treated mathematically, so that the paper does not admit of a satisfactory abstract.

T. H. P.

1878. *Hydration of Dissolved Substances.* I. **W. Nernst.** (Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 1. pp. 68–69, 1900.) II. **H. Lotmar.** (*Ibid.*, pp. 70–85, 1900.) III. **C. C. Garrard** and **E. Oppermann.** (*Ibid.*, pp. 86–89, 1900.)—I. The question as to whether, when a substance is dissolved, combination occurs between the solvent and the solute, *i.e.*, the validity of the so-called hydrate theory of solution, cannot be solved by a study of osmotic pressure or of any other phenomenon in which a state of equilibrium in solution is arrived at. For this purpose dynamical phenomena must be considered, since, if the dissolved substance is displaced in the solution, any combined solvent will be carried along with it. The only means of detecting such displacement is by adding some third substance to the solution, and then studying for instance the movement of the dissolved body on diffusion or on electrolysis. The added substance must not be capable of combining with the dissolved body. In the two following abstracts the results of experiments on these lines are given, the conclusion being that in general hydration of the solute is either entirely absent or only takes place to a very limited extent.

II. **H. Lotmar.** From diffusion experiments on solutions of silver nitrate, butyric, acetic and boric acids, the author concludes that the supposition of Mendelejeff and of Pickering that dissolved substances undergo considerable hydration is not correct, since in all cases he finds that the number of molecules accompanying a molecule of diffused substance is very small. The results show further that for every molecule of silver nitrate or acetic acid diffusing in one direction a number of molecules of water diffuse in the opposite direction; this lends confirmation to the view that diffusion is a complex process in which the solvent takes part. In the cases named this diffusion of the solvent is sufficient to overbalance any slight hydration of the dissolved substance which may occur.

III. **C. C. Garrard** and **E. Oppermann.** The authors describe a number of experiments on the electrolysis of solutions of an electrolyte containing also a non-electrolyte. Dilute solutions of hydrochloric, hydrobromic, nitric and sulphuric acids were employed, the non-electrolytes added being sugar, phenol, urea, and acetic acid. The results are not very concordant, but serve to show that the negative ions, Cl, Br, NO_3, SO_4, take with them, in their passage through the decomposing liquid, a number of molecules of water which is least for the nitrate and greatest for the sulphuric residue. T. H. P.

1879. *Stassfurt Salt Deposits and Hydrated Sulphates of Calcium.* **J. H. van't Hoff** and **E. F. Armstrong.** (Preuss. Akad. Wiss. Berlin, S.ber. 28. pp. 559-576, May 31, 1900.)—In a former paper [see Abstracts Nos. 226 and 1114 and 1116 (1900)] the conditions were investigated under which the calcium sulphate deposits were formed, without paying particular attention to its state of hydration. In the present investigation the authors have experimented on the conditions necessary for the deposit of calcium sulphate as gypsum $CaSO_4.2H_2O$, as half-hydrate $CaSO_4.\frac{1}{2}H_2O$, or in the anhydrous form $CaSO_4$. The problem resolves itself into measuring the tension of the water of crystallisation in the crystal at different temperatures; for, if the solution pressure lies between the pressure of gypsum and half-hydrate, then the latter will be the stable form of the salt.

The experimental method finally adopted consisted in measuring the boiling point of a solution of sodium or magnesium chloride which contained gypsum. If more chloride is added, then the boiling point will be raised, provided the gypsum is not giving up any of the water of crystallisation. More and more chloride is added and the boiling point raised until at a certain temperature it becomes constant for a time in spite of the continued addition of chloride. This point corresponds to the conversion of gypsum into half-hydrate and water at the barometric pressure. By enclosing the apparatus and working under reduced pressures a curve can be drawn of the variation of the pressure in the gypsum crystal with temperature. The results of the experiments are plotted in curves in the paper, and the following formula is deduced—

$$\log p_g = \log p_w + 1{\cdot}493 - \frac{567{\cdot}7}{t + 273}$$

where p_g is the pressure in the gypsum crystal and p_w the maximum vapour pressure of water both at the same temperature t. J. B. H.

1880. *Driving Energy of Physico-chemical Reaction.* **T. W. Richards.** (Amer. Acad., Proc. 35. pp. 471–480, May, 1900.)—In van't Hoff's equation $d \log K/dT = U/RT^2$ the general form of K is $\Pi c_1^{n_1}/\Pi c_2^{n_2}$ or $\Pi v_2^{n_2}/\Pi v_1^{n_1}$, wherein

U denotes the diminution of intrinsic energy during isometric reaction, c the concentration of any component, v its specific volume, n the number of its reacting gram-molecules, and the subscripts 1, 2 refer respectively to the factors and products of the reaction, while Π signifies the product of all the magnitudes of the given type. On substitution from the gaseous relations of type $c = v^{-1} = p/\mathrm{RT}$ the equation becomes

$$d\log(\Pi p_1^{n_1}/\Pi p_2^{n_2})/d\mathrm{T} = \mathrm{V}/\mathrm{RT}^2,$$

where $\mathrm{V} \equiv \mathrm{U} - (\Sigma n_2 - \Sigma n_1)\mathrm{RT}$ is the heat of isopiestic reaction; and of this Clausius' equation, $d\log \mathrm{P}/d\mathrm{T} = \lambda/\mathrm{RT}^2$, is a special case.

The former equation having been called the "reaction-isochor," the author terms the latter the "reaction-isobar," and he includes both in a "reaction-metatherm"

$$d\log(\mathrm{T}^{\mathrm{N}}\,\Pi p_1^{n_1}/\Pi p_2^{n_2})/d\mathrm{T} = -\mathrm{Q}/\mathrm{RT}^2,$$

where N is defined by $\mathrm{N} \equiv \mathfrak{N}(\mathrm{P}_2 - \mathrm{P}_1)/\mathrm{P}_1$; herein Q denotes the actual heat *absorbed* in the reaction, $\mathfrak{N}$ the total number of gram-molecules in the initial reacting mixture, P_1, P_2 the initial and final total gaseous or osmotic pressures.

This equation is taken to be a mathematical expression of the theorem of Maupertuis or Le Chatelier, and is further written in the form

$$d\log(\mathrm{T}^{\mathrm{N}}\,\Pi z_2^{n_2}/\Pi z_1^{n_1}) = -\mathrm{Q}/\mathrm{RT}^2,$$

a train of ideas having caused the author to *assume* that each substance in the mixture has a special "physico-chemical potential" z such that

$$\Sigma n_1 \log(p_1 z_1) - \Sigma n_2 \log(p_2 z_2) = 0,$$

and such too that $\log z^n$ is a measure of the special reaction-tendency of the substance. The equation then shows that a reaction which absorbs heat will have a greater tendency to take place if the temperature is raised.

An application of this theory to certain special cases is then indicated.

R. E. B.

1881. *Physical Reactions and the Mass Law.* **A. T. Lincoln.** (Journ. Phys. Chem. 4. pp. 161–187, March, 1900.)—Bancroft has extended the law of mass action to "physical reactions" by making use of fractional, in place of integral, indices. The formula

$$\frac{xy^{n-1}}{z_1^{n}} = \mathrm{C},$$

given by Taylor (Journ. Phys. Chem. 1. 30, 1897), can be used to represent the weights or volumes of water (x), benzene (y), and alcohol (z) which are present when two liquid layers are about to appear or disappear in a mixture of the three substances in different proportions. In the present investigation it is shown that Taylor's formula gives exceedingly accurate results, especially when the mixtures are prepared gravimetrically, the deviations being usually less than one-third per cent. For both weights and volumes $n = 1{\cdot}525$, and, as Taylor showed, this constant does not depend on the temperature; $c = 0{\cdot}4949$ for gravimetric measurements at 25° C, and 0·5767 at 10° C.

T. M. L.

1882. *The System Water, Phenol, and Hydrochloric Acid.* **W. H. Krug** and **F. K. Cameron.** (Journ. Phys. Chem. 4. pp. 188–192, March, 1900.)—The temperature at which phenol melts under water is raised by the addition of hydrochloric acid (Bancroft, Journ. Phys. Chem. 1. 420, 1897) and quantitative measurements are now given. The melting point is raised from 1·365° to 2·298° by 3·4028 grams HCl per litre, to 4·000° by 13·1323 grams, to 7·100° by 32·8514 grams, and to 17·195° by 131·3234 grams. T. M. L.

1883. *Refractometric Determination of the Composition of Coexistent Phases in Mixtures of Acetone and Ether.* **E. H. J. Cunaeus.** (Phys. Zeitschr. 1. pp. 316–317, April 14, 1900.)—The external pressure was altered, and the composition of the vapour ascertained by determining its refractive index by means of Rayleigh's interferential method, assuming the validity of the law of mixtures, and making allowance for the deviations from Boyle's Law. The composition of the liquid was known from the initial weighings and the quantity of vapour present. The results are given in a short table, from which it appears that there is no maximum or minimum of vapour-pressure. The experimental data are not in accordance with the formula given by van der Waals (Archiv. Néerl. 24. p. 44). F. G. D.

1884. *Distillation of Liquid Air and Composition of the Gaseous and Liquid Phases.* **E. C. C. Baly.** (Phil. Mag. 49. pp. 517–529, June, 1900. Paper read before the Physical Society of London.)—Liquid mixtures of oxygen and nitrogen were allowed to boil in vacuum-jacketed vessels. At successive points of time samples of the gas were collected for analysis and simultaneous readings of a Callendar's compensated hydrogen-thermometer taken. The bulb of the latter dipped into the liquid. The composition of the boiling liquid at successive moments was ascertained by sucking it out through a capillary tube attached to a water-pump. This tube was provided with a T-piece, so that samples of the gas resulting from the *en masse* vaporisation of the liquid could be collected for analysis. Corresponding temperature-measurements were also made. The results so obtained are plotted in a diagram with absolute temperatures as ordinates and oxygen-percentages as abscissæ. In this diagram the corresponding compositions of the gaseous and liquid phases can be seen at a glance, and its employment enables one to determine the temperature of a given sample of liquid air boiling in a vacuum-vessel by an analysis of a sample of the gas given off.

When the logarithms of the ratios of oxygen to nitrogen in each phase are plotted against each other, the points so obtained lie almost exactly on a straight line, *i.e.*, the equation $\log r' = a + b \log r$ holds, where r' and r denote the ratios just mentioned. In the present case it is found that $r' = 0{\cdot}2097\ r^{1{\cdot}06737}$, in which r' and r represent the above ratios multiplied by 100. This is, of course, only an empirical formula, and does not hold at the extreme limits. The boiling points of oxygen and nitrogen as determined by the author are 90·96 and 77·54 respectively ($p = 760$ mm.). The vapour-pressures of oxygen and nitrogen were calculated for every half degree between the above temperatures from the author's boiling-point and vapour-pressure measurements by means of Ramsay and Young's linear law. Reference is made to the extraordinary tendency to superheat which liquefied gases exhibit even when "boiling" fairly rapidly. F. G. D.

1885. *Heat of Ionisation.* **R. Abegg.** (Phys. Zeitschr. 1. pp. 212–213, Feb. 10, 1900.)—Great heats of dissociation are due to intramolecular chemical

reactions such as isomerisation, polymerisation, and hydration, which depend upon ionisation. Hence water has the greatest heat of dissociation, about —13,000 calories, and the formation of H and OH ions is preceded by depolymerisation. Among acids, violuric acid has the high heat of dissociation of — 3,700 calories. This is in accordance with Guinchard's observation that it undergoes an intramolecular change previous to ionisation, and that its conductivity, and hence also its dissociation constant, has a high temperature coefficient. E. E. F.

1886. *Taste of Acids and Ionisation.* II. **T. W. Richards.** (Journ. Phys. Chem. 4. pp. 207–211, March, 1900.)—It has been shown that weak acids and acid salts have a more strongly acid taste than is demanded by their degree of dissociation, on the assumption that the sourness is caused by hydrogen ions. This can be explained either by supposing that the undissociated molecules and anions contribute to the taste, or by supposing that owing to chemical action at the nerve-endings on the tongue-surface the hydrogen ions are removed from the sphere of action, and their place consequently taken by fresh ones owing to the dissociation-equilibrium. Ionisation being an excessively rapid process, a weak acid might accordingly cause a degree of sourness out of all proportion to its strength. The author inclines to the latter explanation as the true one [see also Abstracts Nos. 535 (1898), and 1326 (1900)]. F. G. D.

1887. *Absorption of Nitrogen and Hydrogen by Solutions of Ionised Substances.* **L. Braun.** (Zeitschr. Phys. Chem. 33. pp. 721–739, June 15, 1900.)—It has been shown by Jahn that if α and α' represent the absorption coefficients at the same temperature of a gas in water and in an aqueous solution of an electrolyte containing G gramme-molecules of dissolved substance per unit volume, respectively, then the value of $(\alpha - \alpha')/G^{2/3}$ is constant. Roth found this relation to hold for the absorption of nitrous oxide by solutions of phosphoric acid and sodium chloride, and showed further that by applying Planck's equilibrium law to dilute solutions of gases in solvents having no chemical action on them, the relation $C_1/C_2 = 1$ can be derived; C_1 and C_2 being the molecular concentrations of the gas in pure aqueous solution and in a solution of the indifferent substance respectively—temperature and partial pressure being identical in the two cases. The author's investigations on the absorption of nitrogen and hydrogen by solutions of the non-electrolytes, urea and propionic acid, and of the electrolytes, sodium and barium chlorides, show that for non-electrolytes the equation $C_1/C_2 = 1$ holds with a fair degree of accuracy even for concentrated solutions. For solutions of the two chlorides the value of C_1/C_2 is for medium concentrations considerably greater than 1, and only attains this ideal value for very dilute solutions; the results are, however, in complete accord with Jahn's empirical law: $(\alpha - \alpha')/G^{2/3}$ = a constant. Also for solutions of the same electrolyte, the ratio of the values of this expression for nitrogen and hydrogen is constant at all temperatures (5° to 25°); this is not the case for nitrous oxide and nitrogen, or nitrous oxide and hydrogen. T. H. P.

1888. *Degree of Ionisation and Ionisation-Equilibrium in Strongly-Ionised Electrolytes.* Part I. **H. Jahn.** (Zeitschr. Phys. Chem. 33. pp. 545–576, June 1, 1900.)—Regarding the well-known disagreement between theory and experiment in the case of the dissociation-equilibrium in highly-dissociated electrolytes as due to the influence exerted on the nature of the solvent medium by

the enormous ionic charges, the author points out that this influence is likely to affect the mobility of the ions, although its effect has been usually sought for in an alteration of the dissociation-equilibrium. The object of the present paper is to find out if the mobilities of the ions are functions of the ionic concentrations. Having pointed out the error involved in the usual determination of degree of ionisation from conductivity measurements if such be the case, the author proves the equation $UC = 1{\cdot}0358\frac{n \times k}{\nu} \times 10^{-2}$, where U = mobility of kation (*i.e.*, velocity of kation under a potential-gradient of 1 volt per cm.), C = concentration of kations (in grm. mols), n = migration-constant of kation, k = specific conductivity of electrolyte in reciprocal ohms, ν = valency of kation. The quantities on the right-hand side of this equation can be all determined experimentally, so that the value of UC can be found. Suppose now the values of UC are determined for a series of solutions of varying concentrations, and the products U_1C_1/U_nC_n, U_2C_2/U_nC_n calculated. If the values of C_1/C_n, C_2/C_n be determined by measurements of concentration-cells and application of Nernst's formula, then the quotients U_1/U_n, U_2/U_n can be found, and so the variability or constancy of U can be tested. Such in brief is the author's method. The experimental portion of the paper deals with the determination of the quotients C_1/C_n, C_2/C_n, &c., by means of measurements of the E.M.F.'s of concentration-cells. Proceeding in this way it is found that the mobilities of K, H, and Na in solutions of KCl, HCl, and NaCl respectively *increase* considerably with *decreasing* concentration. Furthermore, by assuming complete ionisation in solutions of N/600 concentration, and thereby deducing actual ionic concentrations from the ratios given by the E.M.F. measurements, the author succeeds in verifying the Ostwald-Planck dissociation-formula for dilute solutions of the above-mentioned electrolytes. There is a want of agreement in stronger solutions, but the author ascribes this to the failure of Nernst's formula for solutions which are not sufficiently dilute. F. G. D.

1889. *Isohydric Solutions.* **W. D. Bancroft.** (Journ. Phys. Chem. **4.** pp. 274–289, April, 1900.)—The statement of Arrhenius that no change of dissociation occurs on mixing isohydric solutions cannot be upheld except in the case of binary electrolytes, and then only if Ostwald's law of dilution holds good. The more extended theory given in the paper shows that in many cases an increase or decrease of dissociation is to be expected, but these conclusions have not been verified by experiment. T. M. L.

1890. *Ionisation of Dilute Solutions.* **W. C. D. Whetham.** (Roy. Soc., Proc. **66.** pp. 192–208, April, 1900; Roy. Soc., Phil. Trans. **194.** pp. 321–360, 1900.)—The author examined conductivities at 0° C so as to obtain data which could be really compared with measurements of ionisation by the freezing-point method. The distillation of the water and the measurements were carried out in platinum vessels. In measuring the conductivity, alternating currents were used, but a commutator was introduced so as to include a galvanometer in place of a telephone. Results are given for sulphuric acid, barium chloride, potassium chloride, potassium bichromate, copper sulphate, potassium permanganate, and potassium ferricyanide. These results are plotted in the form of curves between the equivalent conductivity and $m^{\frac{1}{3}}$, a number proportional to the average nearness of the molecules, m being the concentration. The ionisation curve at 0° is appreciably different from that at 18°. The curves are generally straight lines, but those referring to sulphuric

acid, potassium permanganate, and potassium bichromate are abnormal in this respect. In the case of sulphuric acid there is a very marked drop in the ionisation at extreme dilution, which is not satisfactorily explained by interaction between the acid and residual impurities in the solvent as the phenomenon is very constant. This explanation may be sufficient, however, to explain the smaller drop observed in the case of potassium permanganate. In the case of these two bodies, the solutions require time to reach a steady conductivity after the first addition of solute to solvent. The curve of potassium bichromate appears to consist of two parts, which may indicate that the ions are different at different concentrations. W. R. C.

1891. *Storage Battery Problems.*—**E. J. Wade.** (Inst. Elect. Engin., Journ. 29. pp. 460–495; Discussion pp. 495–521 and 524–530, May, 1900.)—The author puts forward the theory that at the beginning of the discharge of a lead cell the two plates consist of *allotropic* lead and *allotropic* peroxide. On discharge the molecules, still maintaining their complex structure, pass through a long series of true compounds containing SO_4 in gradually increasing proportions. This absorption of SO_4 continues until the internal resistance rises rapidly, indicating the end of the discharge. Charging is practically a reversal of these changes. The author is of opinion that not more than 50 per cent. of the active material can be sulphated, owing to increase of resistance. If that is so, 1 lb. of lead and 1 lb. of peroxide should give 59·25 and 51·25 ampere hours respectively as a maximum. In practice pasted electrodes hardly ever give more than thirty to forty ampere-hours per lb. of active material, and there is a very considerable falling off in the specific output as the discharge rate is increased. To obtain maximum output the porosity must be molecular. Most negative active material has such porosity because it is obtained by reduction, but this is not so in the case of the peroxide. In the latter, substances added to give porosity only separate the particles and cannot give rise to "molecular porosity." Negative active material may have a 50 per cent. porosity (*i.e.*, may hold its own volume of liquid); peroxide will not generally have more than a 33 per cent. porosity. Since solid lead requires twenty-four times, and solid peroxide sixteen times, its volume of dilute sulphuric acid (sp. gr. 1·200) for 50 per cent. sulphation (with a fall to 1·150 sp. gr.), negative and positive active material of good quality can only contain $\frac{1}{24}$th and $\frac{1}{32}$nd respectively of the necessary acid for complete discharge. The author traces out the discharge and charge of a cell, and the effect upon it of insufficient diffusion. This diminishes the output and the durability, and reduces the efficiency. Improvement can only be obtained by striving for "molecular porosity," every molecule of the active material being sufficiently exposed to be acted upon.

In the second part of the paper the author deals more particularly with polymerisation. The utility of lead in storage cells is due not only to the insolubility of the active materials but also to its property of forming complex salts. The author mentions a number of complex lead compounds in support of the idea of polymerisation, and gives the steps involved in taking a plate through discharge, reversal and recharge, assuming that it starts as Pb_{12} and ends as $Pb_{12}(O_2)_{12}$. The chain of intermediate compounds containing varying proportions of SO_4 and O easily explains the observed phenomena; for example, the presence of peroxide on the negative plate towards the end of complete discharge: the formation of this peroxide sets in before the active material is fully sulphated. The author is of opinion that the internal resistance rises rapidly, and the discharge is practically complete, when the active

materials approach a proportional composition of Pb_2SO_4 and $Pb_2O_2SO_4$ respectively. "Sulphating" would be due to a breaking down of the allotropic bodies. This change may account for the gradual loss of capacity in negative electrodes, which is generally accompanied by shrinking. Sulphating is assisted by local action, and therefore takes place more readily during a period of reversal when both lead and lead peroxide are present as well as sulphate.

Discussion.—**W. E. Ayrton** called attention to the loss in capacity which is caused by taking too low a pressure limit for discharge. This may give rise to failure in batteries for automobiles. He was of opinion that the proposed theory did not account for the fact that the discharge curve of a cell which had undergone a period of rest after charging began with a *rise* instead of a fall. The theory also failed to explain why batteries charged at constant potential had a greater capacity than when charged at constant current. **W. Hibbert** was of opinion that the lead and lead peroxide are not in allotropic forms. He had repeated the work of Darrieus, but failed to obtain similar results in support of an allotropic condition. Loss of capacity on standing is explained by the formation of sulphate through simple chemical action, as had been shown by Ayrton and others. Loss of capacity by too complete a discharge is due to almost complete removal of acid from the pores, and consequent change in the reactions; hydrate is then formed with the production of scale. The termination of discharge cannot be determined by rise in resistance through sulphate, otherwise the value of this resistance would be the same at the end of the discharge and the beginning of the charge, but it is found to fall to $\frac{7}{11}$ths at the beginning of the charge. **G. C. Allingham** preferred a simple sulphate theory, the peroxide being reduced to Pb_2O_3, thus accounting for the 50 per cent. sulphation referred to above. **J. Swinburne** was of opinion that a cell can be completely run down to sulphate. Sulphate is reducible if the necessary contact is obtained, or there is a sufficient admixture of a conductor. **A. E. du Pasquier** gave figures relating to plates which had utilised 84 per cent. instead of 50 per cent. of the active material. **W. Boyd** was of opinion that acid impurities may account for the loss of capacity in the negative plates. **E. J. Wade,** in reply, explained that the loss in capacity of negatives to which he referred was that which takes place gradually in the course of years. The reducibility of lead sulphate is probably determined by its solubility. W. R. C.

1892. *Osmotic Theory of the Voltaic Cell.* **M. Couette.** (Journ. de Physique, 9. pp. 200–208, April, and 269–279, May, 1900.)—After having referred to the divergence of views in France and Germany concerning the seat of the various P.D.'s in a Daniell cell, the author proceeds to give a sketch of the modern thermodynamic theory of the voltaic cell. His method of attacking the subject consists in preventing irreversible concentration-changes by providing every liquid concerned with a semi-permeable piston and a water-reservoir, so that every change of concentration yields its quota of (osmotic) work, and in avoiding irreversible Joule heat by employing a conductor of infinitely small capacity to carry electrical charges from one pole to the other, so that the cell is always open, and the average current infinitely small. The external work can now be expressed as the sum of two terms, one relating to the work performed in moving the carrier against the electrical forces, the other to the work done in moving the osmotic piston. As the whole process is isothermal and reversible, the work-differential is a perfect differential, and so according to the time-honoured method a relation

is obtained between its partial differential coefficients, which on integration yields an expression for the E.M.F. of the cell. The result so obtained is applied to the following special cases :—(*a*) Cell with one liquid, solid depolariser, and two electrodes of the same metal (?); (*b*) Daniell type; (*c*) Concentration cell with electrodes of the first sort; (*d*) Concentration cell with electrodes of the second sort. In carrying out the integrations use is made of the van't Hoff osmotic pressure equation. The results obtained are not new, except in the case of (*a*), where the equation is deduced for the case of *incomplete* dissociation.

Having thus considered the thermodynamic theory, the author proceeds to consider the more special features of Nernst's theory, and begins by reproducing Nernst's treatment of liquid cells and diffusion. The subject of solution-pressure and the P.D. at the interface between a metal and a solution of one of its salts is then briefly sketched and the method described whereby the total E.M.F. of concentration and other cells can be calculated by means of the separate P.D.'s. The author acknowledges here the agreement between the total E.M.F.'s so calculated and those observed experimentally, but remarks that this agreement only proves the correctness of the *separate* terms which make up the expression for the total E.M.F.

In the concluding section of his paper, the author considers French work on the subject. The calculations given here are based on (*a*) The thermodynamical theory given in Section 1; (*b*) "Pellat's Law," according to which the P.D. at the junction of a metal and a solution of one of its salts is *zero*. Consequences are deduced which are not in agreement with Nernst's theory. No experimental evidence is given in order to decide the matter. The author's final summing up is that Nernst's theory only agrees with the observed facts when its results are identical with those given by the purely thermodynamical method.

[The *only* basis for this statement that is given by the author is the "Pellat's Law" referred to above. This law is based on a particular interpretation of experimental facts.] F. G. D.

1893. *Gas Concentration-cells with and without Difference of Level, and a new Species of Gravitation-cell.* **E. Bose.** (Phys. Zeitschr. 1. pp. 228–230, Feb. 17, 1900.)—The author considers a gas-cell containing the same gas at each electrode, but at different pressures. There is a difference of height between the levels of the surface (*i.e.*, of the electrolyte) at each electrode, and the difference of gas-pressure is due to this column of electrolyte. The vapour pressure of the electrolyte is neglected. Let p_1 = pressure of gas at lower electrode, p_2 = pressure at higher, h = difference of level, s = sp. gr. of electrolyte, then in the first place, $sh = (p_1 - p_2)\ 13{\cdot}596$. Further let n_1 = number of atoms in molecule of gas, n_2 = number of charges per atom (*i.e.*, valency), R = gas constant, T = absolute temperature, E_1 = potential-difference, or E.M.F. of cell. From the consideration that for every c.c. of gas which disappears at pressure p_1, one c.c. of the electrolyte must fall a height h_1, we obtain by equating gravitational work to electrical energy :—

$$E' = 0{\cdot}634 \,.\, 10^{-5} \frac{T}{n_1 n_2} \frac{sh}{p_1} \text{ volt.}$$

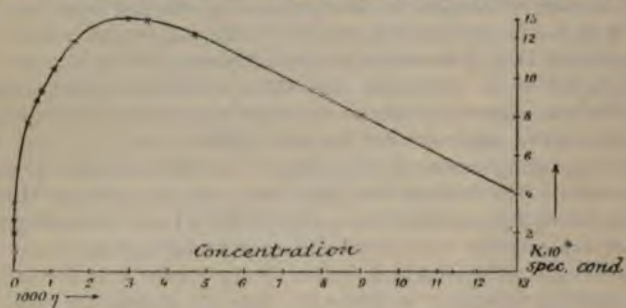
or from above,
$$E' = 0{\cdot}862 \,.\, 10^{-4} \frac{T}{n_1 n_2} \frac{p_1 - p_2}{p_1} \text{ volt.}$$

Viewed as an ordinary concentration cell, we obtain also :—

$$E_1 = 0{\cdot}862 \,.\, 10^{-4} \frac{T}{n_1 n_2} \log \frac{p_1}{p_2}.$$

The total E.M.F. of the cell is the algebraic sum of these two potential-differences. The author shows also how a purely gravitational cell can be obtained by suitably coupling up a cell of the above description with another which contains the same gas at the same pressures at its electrodes, but has no difference of height between the surfaces of the electrolyte. In an experiment on a cell of the sort described above the author obtained the value 0·0050 volt for the total E.M.F. The calculated value was 0·0051 volt, of which about one-half is due to gravitational energy. F. G. D.

1894. *Conductivity of Ammonia Solutions.* **F. Goldschmidt.** (Phys. Zeitschr. 1. pp. 287–289, March 31, 1900.)—It is only in the most dilute solutions that ammonia obeys Ostwald's dilution laws. The dilution function falls rapidly at higher concentrations. The annexed diagram shows the



specific conductivities at various concentrations (mols. per litre). It shows that there is a maximum conductivity at about 3 or 3·5 normal concentration. The author supposes that the ionic velocity of ammonia varies with the concentration. The retardation is small at first, but eventually its effect masks that of the addition of further ions. E. E. F.

1895. *Model to Illustrate Electrolysis.* **E. Müller.** (Zeitschr. Elektrochem. 6. pp. 589–591, June 14, 1900.)—A wooden model is described, consisting essentially of two rows of wooden blocks displaced in opposite directions at different velocities. The blocks represent ions, and their liberation at the electrodes is shown by their falling out of line. The model also explains the accumulation of the electrolyte, say HCl, at one electrode in the course of electrolysis. E. E. F.

1896. *Limiting E.M.F. in the Electrolysis of Chlorides.* **E. Müller.** (Zeitschr. Elektrochem. 6. pp. 573–578, May 31, and 581–583, June 7, 1900.)—The usually accepted value for the limiting E.M.F. for chlorine ions is 1·31 volts. The author, however, advances reasons for considering this value incorrect. The value is based upon results obtained by two methods of observation.

The first depends upon plotting as a curve the currents passing through a solution of a chloride, with gradually increasing E.M.F. At 1·31 volts, or thereabouts, a sharp upward bend occurs in this curve. This, in the author's opinion, only indicates the commencement of some chemical change in the electrolyte, and he shows by the analogy of an electrolyte containing H_2SO_4 and K_2CO_3 that it is probably due to a depolarising reaction, and not to the liberation of gaseous chlorine.

The second method of observation is to note the potential difference

between two platinum electrodes, the one saturated with hydrogen and the other with chlorine gas, when immersed in normal hydrochloric acid. It is assumed that the voltaic chain is represented by—

$$Pt \mid H_2 \quad n.HCl \quad Pt \mid Cl_2,$$

but the author considers it more probable that the chain is as follows :—

$$Pt \mid H_2 \quad n.HCl \quad Pt \mid HClO.$$

The author's own experiments were therefore directed towards noting the changes in the curves obtained by the first method when E.M.F.'s rising beyond 2·0 volts were used, with (1) n.HCl, (2) n.NaOH and n.NaCl, and (3) n.NaCl and $\frac{n}{100}$ NaOH as electrolytes. The results obtained support his theory, and prove that while at 1·31 volts some chemical change is inaugurated at the anode, a far more important change occurs between 2·2 and 2·4 volts. The author does not specifically state that this is the limiting E.M.F. at which the chlorine ions pass into the molecular form, but he maintains that both Wohlwill and Lorenz, who have published results of their work on this subject, have failed to use in their investigations a sufficiently high potential, and have only explored the range of E.M.F. at which depolarising changes are occurring.

The remainder of the author's paper deals with the various equations which may represent what is occurring at the anode at these lower E.M.F.s. The equation—

$$\bar{O}\bar{\ }(++) + \bar{Cl} = \bar{Cl}O,$$

corresponds to the value 1·31 volts, and the author is inclined to believe that this is the depolarising reaction which has been mistaken by other observers for the change represented by

$$\bar{Cl}(+) + \bar{Cl}(+) = Cl_2.$$

J. B. C. K.

1897. *Electrolysis through Semi-permeable Membranes.* **B. Moritz.** (Zeitschr. Phys. Chem. 33. pp. 513–528, June 1, 1900.)—The systems studied were Kathode | $CuSO_4$ | Membrane | K_4FeCy_6 | Membrane | $CuSO_4$ | Anode, and the corresponding system with zinc in place of copper. In each case the membrane of zinc or copper ferrocyanide was formed on the parchment paper which separates the compartments of the cell ; the kathode membrane gets thinner during the passage of the current and the anode membrane thicker. At the anode membrane, on which all the measurements were made, polarisation occurs, increasing gradually to a maximum of about 0·22 volts with a current density of 0·105, 0·140, or 0·175 milliamperes per sq. cm., in accordance with Wiedeburg's formula (Wied. Ann. 51. 310, 1894)—

$$p = \frac{AP(1 - e^{-xt})}{A - Pe^{-xt}},$$

where A is the E.M.F. of the primary current, P the maximum E.M.F. of polarisation, and x a constant depending on the nature of the cell. If the current density is further increased, a constant maximum E.M.F. of polarisation no longer occurs, and the polarisation increases with the current-density. On gradually increasing the current at intervals of three minutes it was found that the polarisation steadily increased, but in one experiment with a copper ferrocyanide membrane a *maximum* E.M.F. of polarisation of 1·006 volts was

observed at a current density 7·950, and on further increasing the current density to 19·080 the polarisation decreased to 0·898 ; in the other experiments this maximum was not reached. T. M. L.

1898. *Anodic Changes during Electrolysis of Chlorides.* **F. Foerster** and **H. Sonneborn.** (Zeitschr. Elektrochem. 6. pp. 597–604, June 21, 1900.)—The liberation of oxygen gas at the anode which always accompanies the electrolysis of solutions of the alkali metal chlorides, and increases with the concentration of $\bar{ClO}$ ions in the electrolyte, has been ascribed by some investigators to the electrical discharge of these $\bar{ClO}$ ions, and by others to the discharge of the $\bar{OH}$ ions present in the electrolyte.

Le Blanc and Haber and Grinberg have, however, shown that the electrolysis of a dilute solution of hydrochloric acid yields free oxygen at the anode, although the conditions preclude the presence of free hypochlorous acid. The authors' aim in the present research has been to clear up this question of the origin of the anodic oxygen. The apparatus used in their experiments is first described, and the methods of analysis used for the determination of the products of electrolysis at the anode are explained. The experiments were so conducted that in each case a neutral and *hypochlorite free* layer of electrolyte separated the anode and kathode divisions of the cell. The evolution of oxygen at the anode could not therefore be attributed to hypochlorite formed by diffusion of sodium or potassium hydrate into the anode division of the cell. The results of a large number of experiments show that portions of the current varying from 0·09 per cent. up to 6·3 per cent. were accounted for by the free oxygen collected at the anode ; the largest volume of oxygen being found with a dilute electrolyte and high E.M.F. The solution surrounding the anode after electrolysis was also examined for chlorate, but the difficulty of estimating its amount correctly in such a solution renders the results somewhat unreliable.

The authors carried out a third set of experiments, using a dilute hydrochloric acid solution as electrolyte. The amount of oxygen found in the anode gas was lower than in the two other series of experiments with neutral chloride solutions, and was also lower than that observed by Haber and Grinberg.

As a result of their investigation the authors state that the presence of oxygen in the gases from the anode, when solutions of neutral chlorides are electrolysed, must be attributed to the hypochlorites or hypochlorous acid present in such solutions as a result of secondary reactions.

They finally discuss the bearing of their experiments and conclusions upon the theories of chlorate production advanced by Wohlwill and by Lorenz and Wehrlin. J. B. C. K.

1899. *Electrolytic Potassium Chlorate.* **A. Brochet.** (Comptes Rendus, 130. pp. 1624–1627, June 11, 1900.)—The author refers to the work of Haber and Grinberg, Wohlwill, Foerster, Jorre, Müller, Lorenz, and Wehrlin, and of Oettel relating to the formation of chlorates in the electrolytic cell. The majority of these investigators have maintained that under certain conditions the formation of chlorate in the electrolytic cell is due to a primary or ionic reaction.

In a previous communication the author has proved that in neutral or slightly alkaline solutions the chlorate is formed from hypochlorite, *i.e.*, that its formation is due to a secondary reaction. In the present communication he

proves that this theory is also true for alkaline solutions. The proof is based upon the use of cobalt oxide in the cell during electrolysis. This oxide decomposes hypochlorites with evolution of oxygen, but has no action upon chlorates. A cell containing an alkaline solution of potassium chloride yielded 48 per cent. of the oxygen at the anode as chlorate upon electrolysis; but when cobalt oxide was added and the experiment repeated under precisely similar conditions, only 2 per cent. of chlorate was obtained. The author therefore concludes that, contrary to the views of Oettel, Haber and Grinberg, Foerster, Jorre, and of Müller, the formation of chlorate in an alkaline solution by electrolysis is *never* due to a primary reaction between OH and Cl ions. Details of the experiment are given. J. B. C. K.

1900. *Electrolysis of Aliphatic Alcohols.* **K. Elbs** and **O. Brunner.** (Zeitschr. Elektrochem. 6. pp. 604–609, June 21, 1900.)—The authors refer to the work of previous investigators in this subject, especially to that of Dony-Hénault. Their own work is supplementary to that of these earlier investigators, and relates to the anodic changes in aqueous solutions of the aliphatic series of alcohols when electrolysed with platinum, platinum black, or lead peroxide anodes and nickel kathodes. The solutions were rendered conducting by the addition of a small amount of sulphuric acid. The cell was constructed in such a manner that the gases from the anode compartment could be collected and analysed. Details are given of the methods used for testing the mixed gases, and also the liquid remaining in the anode compartment after electrolysis. The following alcohols were electrolysed, with the results named :—

Methyl Alcohol.—The products were formic aldehyde, formic acid, carbon dioxide, and carbon monoxide. The first-named was chief product when using metallic platinum as anode, while carbon dioxide increased in volume when platinum black was substituted, and became chief product when lead peroxide was used.

Ethyl Alcohol.—In general the products were the same as with methyl alcohol, but acetic acid was chief product in place of the corresponding aldehyde, and under the best working conditions 80 per cent. of the current could be utilised for this oxidation of the alcohol.

N. Propyl Alcohol.—The production of the aldehyde diminishes as one ascends the series of alcohols, and with *n*. propyl-alcohol, propionic acid becomes chief product with all three forms of anode material. A 90 per cent. current efficiency can easily be attained in this oxidation.

Iso-Amyl-Alcohol.—The corresponding acid, isovalerianic acid, was chief product by the electrolysis of this alcohol. The corresponding aldehyde was present in traces, and only increased in amount when very low current densities were employed. It was found that the lead peroxide anode was also able to effect this oxidation alone, at the normal temperature.

Iso-Propyl-Alcohol.—The products in this case were acetone, acetic acid, formic acid, and carbon dioxide. A 70 per cent. current efficiency in the yield of acetone could be obtained under certain conditions, but this oxidation product was easily subject to further oxidation with production of acetic and formic acids.

An attempt was made to repeat the experiment with an alkali in place of sulphuric acid for imparting conductivity to the solutions, but it was found that condensation products of the aldehydes were formed at the anode.

J. B. C. K.

1901. *Electrolytic Processes for Alkalies.* **J. G. A. Rhodin.** (Soc. Chem. Ind., Journ. 19. pp. 417–419, May, 1900.)—The author deals with his subject historically and subdivides it under two heads, viz., processes involving the use of a diaphragm for keeping the products at the two poles separate and processes employing mercury as a kathode for retaining the sodium as sodium amalgam, from which it can subsequently be recovered as sodium hydrate. It is, however, nearly impossible to make a strong solution of alkali in the former, as the alkaline hydrate, having a lower decomposition value, after a short time is acted upon by the current, in preference to the chloride with the formation of hydrogen mainly at the negative. The Hargreaves & Bird process and the question of lowest voltage at which salt can be decomposed is next discussed. Subsequently the patents dealing with a mercury kathode are given in chronological order and the differences between them explained. Finally, mention is made of the Hulin & Vautin processes for electrolysing alkaline chlorides in the fused state. J. L. F. V.

1902. *Electrolytic Hypochlorite fot Bleaching and Disinfecting.* **J. B. C. Kershaw.** (Electrician, 45. pp. 289–291, June 15, 1900.)—An account is here given of the most important processes and apparatus for the production of bleaching solutions from alkaline and magnesium chlorides. Those of Hermite, Stefanow, Kellner, Woolf, Corbin, and Vogelsang are discussed, mention being made of the master patent of C. Watts, No. 13755/1851, which contained the essential features of these methods.

The conditions necessary for the production of bleaching solutions are essentially the following: (1) Insoluble electrodes. (2) No diaphragm. (3) Low temperature of the electrolyte. (4) Rapid circulation from kathode to anode.

Electrolysers for the production of hypochlorites are then described. Hermite's electrolyser consists of a long, shallow, open tank containing two sets of revolving zinc discs as kathodes entirely immersed, the anodes of platinum gauze being placed in between them. The electrolyte is a solution of sodium chloride (magnesium having been abandoned). For bleaching purposes it seems to have been moderately successful in Sweden, but its use for disinfecting after numerous trials has been given up. For a yield of 1 kilo of chlorine in the form of hypochlorite, 10·2 E.H.P. hours are required.

Stefanow's electrolyser is said to be used extensively in South Russia, but no figures are obtainable. It resembles the Hermite cell, and solutions equal to 6 grams. per litre of available chlorine are the result. Lime is used, and probably prevents the reduction of the hypochlorites already formed by the kathodic hydrogen.

Kellner's electrolyser consists of an earthenware cell fitted with electrodes, centrifugal pump, and enamelled receiver with cooling worm. Circulation of the salt solution is thus maintained till the desired strength is reached. Platinum-iridium wires wound round glass plates form the electrodes. A number of places are mentioned where the apparatus is successfully at work. A current of 114 amperes at 112 volts for three hours yielded 5·5 kilos of active chlorine equal to 9·4 E.H.P. hours per kilo of active chlorine.

Woolf's electrolyser has anodes of platinum-iridium and kathodes of zinc. Sea water is being used at Havana; efficiency, 7·5 E.H.P. per kilo of chlorine.

In the Corbin electrolyser the output equals 11·1 E.H.P. hours per kilo of chlorine and in the Vogelsang apparatus 6·6 E.H.P.

The author then proceeds to calculate the power necessary, assuming a

minimum E.M.F. of 2·3 volts for decomposing NaCl in solution, and finds it to be 4·78 E.H.P. hours per kilo of chlorine. A comparative table is then given showing that the efficiency ranges between 42 and 71 per cent.

Comparison is made between the cost of chlorine in the form of bleaching powder at £7 10s. per ton, which is 6·8d., and that of the Kellner electrolyser, which is 7·2d. per kilo of available chlorine.

Actual bleaching tests by means of electrolytic and ordinary methods for calico goods show that the cost for the former method is about one-third of the latter, according to a circular by the Kellner Company.

The author arrives at the conclusion that electrolytic bleaching, *i.e.*, sodium hypochlorite, will be found by actual trial not only an efficient, but also an economical bleaching agent in comparison with the materials hitherto in use. O. J. S.

REFERENCES.

1903. *Critical Temperature of Mixture.* **N. J. van der Lee.** (Zeitschr. Phys. Chem. 33. pp. 622–630, June 1, 1900.)—Paper similar to that referred to in Abstract No. 1444 (1900).

1904. *Electro-chemistry.* **M. Bodenstein.** (Phys. Zeitschr. 1. pp. 272–275, March 17; 283–284, March 24; and 291-295, March 31, 1900.)—These papers contain a synopsis of the different technical chemical processes in which the electric current is used, a short description of each being given. J. B. H.

1905. *Electro-chemistry.* **H. Borns.** (Feilden, 3. pp. 23–33, July, 1900.)—This article gives general information with regard to the present position of the electro-chemical industry throughout the world.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

1906. *Use of Gasoline Gas for Boiler Heating.* **H. Poole.** (Mech. Eng. 5. pp. 786–788, June 2, 1900. Paper read before the American Society of Mechanical Engineers.)—During April, 1898, experiments were made with a view to determine whether suitable gas for boiler firing could be obtained by carburetting air by passing it through liquid gasoline. A special gas apparatus was made in which air was forced by blowers through the gasoline, the carburetting chamber being capable of being heated by steam if necessary to assist the vaporisation. A mixing cylinder was added nearer the boiler, because a small quantity of hydrogen gas, generated in another vessel by the reaction of dilute sulphuric acid on zinc, was, along with air, to be mixed with the gas from the carburetter before ignition. Additional air for combustion was also added in the furnace, but the burners tried were of a crude and more or less unsatisfactory form.

The boiler was a cylindrical multitubular boiler 14 feet long by 8 ft. 6 in. diameter, with 88 flue tubes 3 inches diameter. The heating surface in the boiler was 520 square feet with an additional 111 square feet in a superheater. The general result was that whilst steam could be raised with this fuel, and a very satisfactory distribution of flame could be ensured, the process was too costly. It took 35 gallons of gasoline, costing 10 cents per gallon, to generate 1,000 lbs. of steam at 60 lbs. per square inch pressure. This was equal to an evaporation of 1,211 lbs. of water from and at 212° F., and corresponds to an evaporation of only 34·6 lbs. of water per gallon of gasoline at a cost of about fivepence, or of about 5·3 lbs. of water per lb. of gasoline. The following gives the results of the test.

Summary of Data and Results.

Time of trial		about 2 hours
Grate surface	3 ft. 8 in. by 5 ft. 5 in. or	19·9 sq. ft.
Water heating surface	520 sq. ft.	
Superheating surface	111 sq. ft.	
Total heating surface		631 sq. ft.
Ratio of water heating to grate surface		26 to 1
Ratio of minimum draught area to grate surface		1 to 12
Steam pressure		60 lbs.
Temperature of air		50° F.
" " boiler room		80° F.
" " steam		292·5° F.
" " waste gases at chimney (estimated)		325° F.
Fuel used		Air gasoline gas
Quantity of oil used (estimated)		35 gallons
Weight of oil used		227·5 lbs.
Calorific value per lb.		20,000 B.T.U.
Total weight of water in boiler		12,500 lbs.
Weight of water evaporated		1,000 lbs.
Feed water used		none.

HEAT BALANCE.

Total heat value of 1 lb. of oil used, 20,000 B.T.U.

	B.T.U.	Per Cent.
Heat absorbed by boiler	3,483,250	76·5
Loss due to water formed by combustion of the hydrogen	385,100	8·5
Loss due to heat in the chimney gases	236,600	5·0
Loss due to incomplete combustion	—	—
Loss due to absorption, radiation, &c.	445,050	10·0
	4,550,000	100·0

F. J. R.

1907. *Liquid Fuel Apparatus of S.S. Cardium.* (Engineer, 89. p. 534, May 25, 1900.)—A description of Orde's system of spraying liquid fuel. The oil is pumped from the fuel bunker into a settling tank. Thence it is pumped, at a pressure of about 60 lbs. per square inch, through a heating coil in the smoke box. The spraying steam, and air for burning, are also heated. The hot oil, air, and superheated steam are mixed in an injector burner before being sprayed on broken incandescent fire brick covering the fire bars, through which air is also admitted. It is claimed that complete combustion is obtained by this method. J. T. R.

GAS AND OIL ENGINES.

1908. *Riché Gas Producer.* **P. Corbier.** (Génie Civil, 37. pp. 149–151, June 30, 1900.)—Recent improvements are seen at the Paris Exhibition in an installation for producing gas from wood, suitable for driving gas engines and for heating purposes. The generator consists of two cylindrical retorts of cast-iron placed vertically, and heated to a cherry-red by the gases from wood or coal burned in a central furnace surrounded by masonry. The cut wood is fed into the top of the retort, and the charcoal and residue from the distillation falls to the lower part of the retort, kept at a temperature between 850° and 900° C. to decompose the vapours from the wood passed down through it. The apparatus is easily worked and the gas formed is taken through a hydraulic box to the gas holder, and through a sawdust purifier for use in the gas engine.

The value of the charcoal varies with the kind of wood. Moisture in the wood only requires more fuel in the furnace, but does not affect the quality of the gas produced, probably because the water-gas formed is equal in heating value to the wood-gas. Each retort can distil, per hour, 10 to 12 kg. of wood, making 70 to 90 cubic metres of gas of calorific value of 3,000 calories per cubic metre, or nearly three-fifths that of town gas. The composition by volume of Riché wood-gas is CO_2, 20 per cent.; CO, 20 per cent.; C_2H_4, 15 per cent.; and H_2, 45 per cent. The flame is of high temperature owing to the absence of nitrogen. In practice, 1,000 cubic metres of this wood-gas are produced by distilling 140 kg. of wood, and burning 56 kg. of average quality coal or 160 kg. of wood, and the residue is 26 kg. of wood charcoal.

A water float antifluctuator is also described, which on the one hand prevents sudden changes of pressure in the gas supply, due to the suction of the gas engine, and on the other hand acts as an exhaust silencer. W. R.

AUTOMOBILISM.

1909. *Gobron Petrol Motor.* (Automotor Journal, 4. p. 450, June, 1900.)—This motor is of the two-stroke type and is designed to work upon the well-known crank-chamber suction and compression system. The two features of novelty consist of forming the inlet port, from the combustion chamber into the working cylinder, in the piston head so that the charge enters centrally; and of setting the axis of the working cylinder tangentially to the crank shaft so as to reduce the amount of negative work done by the fly-wheel [according to the inventor]. A sectional drawing of this motor is given. A. G. N.

1910. *G. Richard's Car.* (Automotor Journal, 4. pp. 442–444, June, 1900.)—A fully illustrated description of this vehicle. The chief points of interest are the transmission gearing and the motor governor. The car is of the touring four-seated type and is said to be exceptionally strong and rigid. The gearing is of a kind similar to the well-known Panhard gear, but is driven by a belt, from a double cylinder horizontal petrol motor (in front). The pulley wheel upon the shaft driving the speed-gear is fitted with a friction clutch which enables it to be fixed to or freed from that shaft. The various trains of spur wheels are thrown in and out of mesh in the usual manner. The motor governor is mounted upon the half-speed shaft, which operates the exhaust valves, and is fitted inside a metal drum. It is of the centrifugal type, and it acts upon sliding exhaust cams in such a manner that, as the engine speed increases, the one exhaust valve remains closed throughout the cycle of the engine, and then the other exhaust valve is only opened by its cam for two-thirds or one-third of the exhaust stroke of the engine; if the speed still further increases neither exhaust valve is opened. Variably timed electric ignition is fitted to these machines, motors of either 7 or 10 H.P. are fitted according to requirements, and their speed can be varied from 400 to 1,200 r.p.m. by a handle which acts upon the governor. A. G. N.

1911. *Automobile Waggon for Heavy Duty.* **A. Herschmann.** (Mech. Eng. 5. pp. 724–727, May 26, and 779–781, June 2, 1900. Abstract of a paper presented at the Cincinnati meeting of the American Society of Mechanical Engineers, May, 1900.)—The advantages of self-propelled vehicles are speed, small space occupied, and absence of smell. Damage to the roads owing to their weight is less than that caused by horses' hoofs. Good roads are necessary for successful working, but the saving in their cleanliness and hygienic condition compensates for such additional expenditure. Extra safety is insured in consequence of the rapidity with which a motor vehicle can be stopped; a horse can seldom pull up from full speed in less than thirty yards, but a three-ton car can be stopped in eight yards when travelling at eight miles per hour. Powerful brakes are easily provided and the motor also lends itself, when necessary, to a similar purpose. The limited distance which a horse can travel renders the motor waggon superior in an important respect. A steam waggon is superior to its other mechanical competitors because it has a greater radius of action and because the necessary supplies and fuel, &c., can be easily procured; oil waggons are chiefly inferior because of their difficulties of operation. The tendency with steam cars is to make them larger because their proportionate weight of machinery is less. The actual cost of propulsion is much smaller than with animal traction. The best steam cars have been produced in England. The most serious difficulties arise when they are used on rough roads. No form of rubber tyre is satisfactory for waggons

intended to carry a load of over one ton; steel shields have been tried in combination with rubber, but without success. Steel tyres on stiff wooden wheels have been found to be the best; they strengthen the wheels, and with dished wheels are indispensable. Well-constructed springs should always be used to lessen the shocks on the wheels. The width of the tyre is a subject of divergence of opinion. For waggons up to a capacity of two tons the total width of tyre should be two inches per gross ton carried, for heavier waggons this width should decrease to one inch per ton. Small driving wheels are generally used because of their extra strength and because of the high speed of the motors; apart from these considerations larger wheels (than three feet), say four feet, are better because they do not sink in as deeply when they pass over depressions in the road. Any advantages to be derived from front-driving are more than counterbalanced by the awkward position of the machinery which is necessitated; if all four wheels could be driven in a practical manner it would prove an excellent feature of a waggon. The arrangement of the differential gear on the driving axle, when dished wheels are used, is troublesome; there is room for improvement in this connection. The provision of two different ratio gear-trains is advisable in the transmission gearing. A suitable boiler must be safe, small, quick-steaming, and economic. A shell boiler is preferable to a tubular type in several respects. Coal and coke are more suitable than oil, as fuel, at the present time. In using a shell boiler it is convenient to fire through the boiler top. Condensers are troublesome on motor waggons owing to leaky pipes and the difficulties in running a condenser. Smoke difficulties have been practically overcome. Compound steam engines are convenient because of the powerful starting moment which can be obtained by admitting high pressure steam into the low-pressure cylinder; the cylinder ratio should be larger than with stationary practice because the pressure used is higher. Most waggons hitherto made are too light to stand the severe strain of their work. A heavy car is as easy to stop as a light one. At present the steam waggon is the most successful vehicle for the economical transportation of heavy loads. With horse traction the capacity is limited, running expenses are highest, and fixed charges are lowest; with steam cars the capacity is unlimited, the running expenses are lowest and the fixed charges are highest; for this reason lightness of construction is less important than many people think. (Drawings are given of a steam-driven waggon manufactured by the Adams Express Co., and of a steam waggon shed; these are designed by the author.) A. G. N.

1912. *Tourand Automobile.* (Locomotion Automobile, 7. pp. 358–363, June 7, 1900.)—This car is arranged on somewhat similar general lines to the well-known Daimler vehicles. The motor, the carburettor and the speed-changing gear, however, differ in many essential respects. Full particulars of the machine, with clear illustrations, are given. The motor (invented by M. Crozet) consists of two parallel cylinders having a common combustion chamber, and each actuating a separate crank-shaft. One inlet and one exhaust valve only are used. The crank-shafts are parallel to each other, and are geared together by spur gearing. Each crank is fitted with a balance weight, and the two cranks, which revolve in opposite directions, are so adjusted relatively to one another that the two pistons always reciprocate in unison. Both crank-shafts carry flywheels at one end, but power is taken direct from one shaft only. The motor works on the four-stroke cycle, and develops 7½ B.H.P. The carburettor is of the "spray" type, but does not require any constant *level float device.* The air passage through the mixing

chamber is partly obstructed by a grooved and inverted cone, which is fixed to a needle valve, normally closing the petrol feed to the chamber; when the air is drawn by the piston suction past this cone, it causes the cone and the valve to lift and to thus admit petrol into the air passage. The air then sprays the petrol upon the surface of the cone and thus forms an explosive mixture with it. The petrol feed is regulated by means of a set screw which fixes the degree to which the needle valve can be lifted. The speed gearing is of the well-known spur and bevel wheel type, but the various trains of wheels always remain in mesh with each other, and are called into play alternately, as desired, by means of friction clutches. The total weight of these vehicles is about 15 cwt.; they are fitted with supply tanks of sufficient size for running about 60 miles without attention. A. G. N.

1913. *Pennington's Military Automobile.* (Scientific American, 82. p. 408, June 30, 1900.)—A four-wheeled machine designed for the use of light artillery to carry a couple of Maxim or Colt guns into action rapidly. The framework consists of two longitudinal 3-inch steel tubes, which carry the rear axle and the front steering-wheel heads, and are tied together by cross braces. The motor consists of two water-jacketed, steel tube cylinders, 5¼ in. in diam. by 12 in. stroke; these are placed horizontally, and are connected to a crank shaft, having overhung cranks at either end and a heavy central flywheel between its main bearings. Power is transmitted from either of two chain wheels, on either side of the flywheel, to the rear axle; either of these two different speed-gears can be put into operation by means of friction clutches fitted to the chain wheels on that axle. The machinery is placed so as to give a low centre of gravity, and is protected by a belt of armour. The water tank serves as a wind shield in front. Supplies of water and petrol for running 150 to 200 miles are provided for. Tube and electric ignition are both fitted. The power of the motor is stated to be nearly 40 H.P., and a speed of over 60 miles an hour is said to have been attained on a half-mile track. The wheels are 22 in. diam., and are equipped with 5 in. pneumatic tyres. This machine weighs 1,500 lbs., and will accommodate eight people, a steersman in front, a driver behind, and three passengers on each side. Two photographs of this car are reproduced. A. G. N.

1914. *Merciè Two-speed Gear.* (Automotor Journal, 4. p. 441, June, 1900.) —A mechanism designed for use on light voiturettes or motor-cycles. An arrangement of spur-wheels, on two parallel axes, and of clutches whereby a sleeve mounted about the driving axles may be caused to revolve at either of two speeds, relatively to the axle, or may be disconnected from it entirely. Drawings showing its application to a tricycle and a section of the mechanism are given. A. G. N.

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1915. *American Corliss Engines for Electric Traction.* **C. Day.** (Engineer, 89. pp. 532–533, May 25, and 558–559, June 1, 1900.)—A description and some illustrations of American practice.

1916. *Boiler Testing.* (Mech. Eng. 5. pp. 833–835, June 16; 871–873, June 23; and 909–910, June 30, 1900.)—Articles dealing mainly with the methods of determining the calorific value of the coal and the composition of the flue gases. Full particulars are given of the methods of using the Thomson and the Carpenter fuel calorimeters.

GENERAL ELECTRICAL ENGINEERING.

1917. *Commelin and Viau's Storage Cells.* **J. Blondin.** (Écl. Électr. 23. pp. 452–456, June 23, 1900.)—This is an illustrated article giving general particulars of the construction of two types of cell. Both contain a cadmium sulphate electrolyte from which cadmium is deposited on charge upon a kathode of lead or carbon, and in the one type the anode is simply a slight modification of the usual grid filled with lead peroxide. The other cell is a partial gas battery, for the anodes consist of tubes of carbon, and the oxygen given off from their surfaces on charge is collected under pressure in suitable receptacles, recombining to form water on discharge. No data are given as to the performance of this cell, but some curves of fall of potential on slow discharge rates and figures deduced from these as to output for weight are furnished for the other type. E. J. W.

1918. *Evershed's Frictionless Motor-Meter.* **S. Evershed.** (Inst. Elect. Engin., Journ. 29. pp. 748–781; Discussion, pp. 781–794, July, 1900.)—In this meter, the vertical axle carrying the armature is provided with a step bearing having a jewel cup at its lower end, and with a magnetic suspension at its upper end, whereby nearly the whole of the weight of the axle and parts mounted thereon is removed from the step bearing. This magnetic suspension comprises a bar magnet arranged in line with the axle, so that the induction density remains constant during rotation of the axle; and the pole-piece of the magnet is separated from the upper end of the axle by a plate of non-magnetic material, so that, in the event of the axle being jolted upward, it cannot remain adhering to the magnet. The commutator segments for the armature are fine iridio-platinum wires supported at one end in an ivory collet, and entirely free at the other end, where they impinge and roll on the peripheries of wheels which replace the brushes usually employed. The counting train is driven from the armature without contact by the following device, viz. :—On the upper part of the axle is a solenoidal electromagnet having two coils in series with parts of the drum-winding of the armature, so that the currents therein reverse simultaneously twice each revolution. This electromagnet acts on an annular soft iron armature encirling it, and this armature is mounted at the end of an oscillating lever actuating the counting train through a pawl and ratchet-wheel. By this means, the lever makes a double stroke every revolution of the armature.

This meter has given extremely good results, having a range of at least 1 to 50. The paper includes an account of earlier magnetic suspension devices; appendices giving methods of calculating the armature torque, brake torque, and frictional resistance; and also tabulated tests of some meters.

In the *Discussion,* **W. M. Mordey** described Stanley's magnetic suspension and showed a model. This device consists of a pair of feather-edged discs at each end of the axle, each disc being encircled by a narrow annular pole-piece. The pole-pieces of one pair are connected to the N-poles of e.g. two permanent magnets, while the pole-pieces of the other pair are connected

to the S-poles of these magnets, so that there is a magnetic flux along the shaft which causes the shaft to float in the air. Extensions of the shaft pass through guide holes at each end. C. K. F.

1919. *High-voltage Switches and Fuses.* **Zetter.** (Soc. Int. Élect., Bull. 17. pp. 132–137, March, 1900.)—The best length of break for 220-volt fuses is 2·5 cm. for 2 amperes, 3 cm. for 5 amperes, 3·5 cm. for 15 amperes, and 4 cm. for 30 amperes. E. H. C.-H.

1920. *Acrograph.* **N. S. Amstutz.** (Elect. World and Engineer, 35. pp. 247–250, February 17, 1900.)—A beautiful instrument for translating the variations of relief of a carbon print into corresponding variations in the depth to which a cutter, on a kind of screw-cutting lathe, cuts lines in a metal plate. The result is the formation of a delicate reproduction in the form of an engraved plate, suitable for printing from, without injury to the carbon print. A. D.

1921. *Testing Electric Railway Systems.* (Street Rly. Journ. 16. May, 1900. Supplemental Chart.)—In this chart, 11 tests are given, viz., for bonds; current flow in water-pipes; drop on ground return circuits; local earth resistance between pipe and rails; relative conductivity of rail and pipe returns; location of grounds or leaks; line conductivity; equalisation of compound-wound generators; and equalisation of motors. C. K. F.

1922. *Transmission Dynamometer.* **W. E. Goldsborough.** (Amer. Inst. Elect. Engin., Trans. 17. pp. 219–227, April, 1900.)—The author states that the principles upon which the success of his dynamometer depends have been already used in several other instruments; it is in the adaptation of these principles that the chief novelty consists. It consists roughly of a shaft made in two parts, one of which is turned down so that its end exactly fits a concentric hole bored in the other part. Each section of the shaft is provided with a spiral grip thread turned to fit a spiral spring. The ends of the spiral spring are fastened with jaw collars, which not only hold the end turns of the spring very securely, but also prevent them from springing out when the direction of rotation is such as to tend to unwind the spring. The angular displacement of the spring can be measured to within the fifth part of a degree by an ingenious electrical device. Two brushes are held by two brush-holders which are mounted on the dynamometer bearings, and are fitted with 90° graduated scales. The brushes are carried on insulated brush-rods, and are connected with one another through primary batteries and a telephone. This circuit is only completed when the brushes make contact at the same instant with two metal pins carried on wheels fastened to the two portions of the shaft. When the brush-holders are in the proper position a click will be heard in the telephone at every revolution of the dynamometer shaft. If ordinary conditions of constant load are maintained, the author states that the relative motion between the contact points will be zero, even with the lightest spring he uses, and hence the frequency of the click is constant. With his dynamometer he determines the full load torque within one-tenth of 1 per cent.

The author gives the results of a very complete and interesting test he made on a three-phase motor. He joined this motor by means of his transmission dynamometer, to what practically was a direct-current series dynamo. By this means he obtained great stability at all loads. This was owing to the

fact that the torque of the direct-current machine increased very nearly as the square of its armature speed, and therefore very much faster than the torque of the induction motor. The torque can thus be measured at all speeds and not merely for speeds below the speed of maximum torque.

Diagrams are given of the dynamometers, and full details of the shaft and spiral spring clutch jaws are also given. A very simple method of calibrating the dynamometer is described. The whole operation of taking out one spring substituting another, and calibrating it need not take more than ten minutes. After adjustment it may be placed in the hands of inexperienced experimenters, as there is nothing to get out of order. A. R.

1923. *Apparatus for Determining the Relative Crank Positions of Two Engines in Motion.* **P. v. Kowaleff.** (Elektrotechn. Zeitschr. 21. pp. 502–503, June 21, 1900.)—It has been stated that certain types of alternators will run in parallel satisfactorily only if the cranks of the engines driving them are in corresponding positions. This is probably true where large equalising currents are necessary to keep the machines in step. But when the equalising currents are small, it would probably be best to run the machines so that steam admission does not take place simultaneously in all the engines, but consecutively. Such an arrangement would have the double advantage of reducing speed fluctuations and exposing the steam pipes to the least amount of shock. In any case it is interesting to have some means of ascertaining the relative crank positions of two engines which are in motion. For this purpose the author has devised the apparatus shown in Figs. 1 and 2. A suitably constructed voltmeter V (Fig. 2) is joined in series with a source of E.M.F. Q (either continuous or alternating), and two two-way switches, u_1 and u_2,

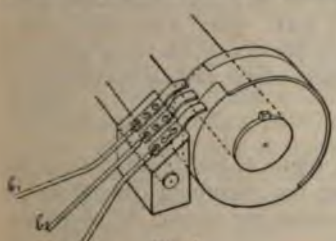

Fig. 1.

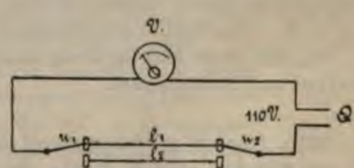

Fig. 2.

mounted on the shafts of the two machines respectively. The moving part of the voltmeter has a large moment of inertia, and its motion is strongly damped. The contacts of the two-way switches are connected by means of two wires, l_1 and l_2. The construction of the two-way switches is shown in Fig. 1. A sleeve of insulating material mounted on the crank-shaft, carries a specially-shaped ring of metal, the central portion of which forms a continuous ring, while the side portions consist of semicircles. Three brushes, placed as shown, serve to bring about the periodic change of connections. It is obvious that when the switches, u_1 and u_2 work co-phasally, the voltmeter reading will be at its maximum, while, if there is opposition of phase, the reading will be zero. Intermediate phase differences give intermediate readings. For the purpose of calibrating the arrangement, the two switches are mounted side by side on the same shaft, with an arrangement for displacing the one relatively to the other. The shaft is then rotated approximately at the speed of the engine, and the readings corresponding to various angular displacements of the two switches are noted. A. H.

1924. *Heating of Underground Cables.* **K. Wilkens.** (Elektrotechn. Zeitschr. 21. pp. 413–416, May 24, 1900.)—In continuation of the work of Kennelly, the author investigates the problem of finding the rise in temperature in a given conductor and a given dielectric, when surrounded by media of different thermal capacities and different thermal conductivities, with a view to determining the maximum safe electric current, as regards temperature, for any specified cable. The thermal equation gives an expression for the rise in temperature between two points in the thermal path normal to the conductor, in terms of the distance between the two points, the mean dimensions of the path, the quantity of heat evolved in the conductor, and the thermal constants of the material. The quantity of heat per second, corresponding to a given current in the same conductor, is then expressed in watts; and, making certain assumptions, equations are found—(1) For the distance between the two points, as above, for a given difference of temperature between them; and (2) for the thermal resistance (*Wärmeleitungswiderstand*) of the thermal circuit. Experiments are described in which observations are made of the rise of temperature in particular cases, corresponding to various currents in the conductor of a cable. An iron tube, filled with oil, was heated electrically by an enclosed spiral of wire. This tube was buried in a horizontal position in the earth. Temperature observations were made by means of a thermometer in a vertical oil-tube, communicating with the main tube. During the experiments the vertical tube was surrounded with snow. Similar tests were made in which the tubes were submerged in wax, sand, water, and air respectively. The author does not say how the difficulties of convection currents in the oil tubes were overcome, there is consequently some doubt as to how the results are to be interpreted. His relative figures for thermal resistance, as measured in a particular case after twenty-four hours' steady current, are: wax, 3·29; water, 4·98; sand, 5·23; air, 11·8. The results are tabulated, and curves are drawn, showing the radii of the heat zones and the temperature differences under various conditions of current and environment. R. A.

1925. *Heating of Underground Cables.* **R. Apt.** (Elektrotechn. Zeitschr. 21. pp. 613–617, July 26, 1900.)—In calculating the maximum current which an underground cable may safely carry, it has been the custom to adopt the same formula as for overhead cables, namely—

$$C = k_1 \, d^{3/2}$$

where k_1 is a constant, d the diameter of the cable, and C the current. It is evident that the conditions are quite different in the two cases; in the one there is cooling by radiation, and in the other by conduction. In order to apply the laws of heat conduction to this case, the conditions which the author assumes are that the cable lies along the axis of a cylinder of earth of radius equal to the depth of the cable below the surface, and also that the outside of this cylinder is kept at a constant temperature. He thus obtains the formula—

$$T = \frac{m C^2}{\Delta}$$

where T is the excess of temperature of the cable above that of the surface, C the current in the cable, Δ the section of the copper, and m a constant. This gives, when T is constant, $C = k_2 \sqrt{\Delta}$, where k_2 is another constant, and equal to $\sqrt{T/m}$.

A number of experiments carried out at the cable works of the Allgemeine Electricitäts Gesellschaft gave results which satisfy the above formula.

The cable to be experimented on was buried at a depth of 0·5 m. in a large tank (6·8 m. × 1·5 m. × 1·5 m.) filled with damp sand. The cable was doubled back on itself several times, so that when the current was sent through it, the effect was similar to that of several cables laid side by side, and all carrying the same current. The temperature of the cable was obtained by measuring its resistance.

The results show that the rise of temperature, when the steady state is reached, is proportional to the square of the current, and inversely proportional to the section of copper in the cable. In the equation—

$$T = \frac{mC^2}{\Delta}$$

the constant $m = 0{\cdot}016$ for values of Δ from 25 up to 1,000 mm.², and for values of T up to 50° C. Taking different constant values for T, and calculating the value of the constant $k_2 = \sqrt{T/m}$, we find that it is approximately numerically equal to T + 15, so that if the rise of temperature in the cable is never to exceed 25°, the maximum current which it may carry is given by—

$$C = 40\sqrt{\Delta}$$

C being measured in amperes and Δ in (mm.²). This makes a simple formula for practical purposes, and one easily remembered. J. B. H.

1926. *Cheap Mains for Electricity Supply.* **C. M. Harris.** (Elect. Engin. 25. pp. 880–881; Discussion, p. 881, June 22, 1900. Paper read before the Municipal Electrical Association.)—The paper deals with the lighting of small towns, in which the cost of underground mains is the chief consideration. At Bray the mains are paper-insulated, lead-covered, and laid in puddled clay, and after eight years are as good as new. The system of jointing is described, and a table of tests on the cables is given. Pitch is recommended for filling joint boxes. The cost of laying the cables as above was 1s. per yard, and of making a joint 9s. 6d. It is suggested that low pressure cables may be of bare copper, laid on insulators in troughs filled up with pitch; such cables have withstood 1,000 volts for twelve months without deteriorating at Bray. In the discussion it was stated that the pitch did not attack the lead covering of the cables. A. H. A.

1927. *Standardising Electrical Machinery.* **P. Sellon.** (Inst. Elect. Engin., Journ. 29. pp. 291–303; Discussion, pp. 304–344, April, 1900.)—The absence of standardisation in England is due to the purchasers being unconnected with manufacturing interests, the engineer acting for the purchaser being frequently tempted to specify "showy" divergencies in minute detail instead of simply stating the ends required by the buyer. With repetition manufacture, the makers will guarantee results. Competition between manufacturers will be sufficient to prevent stagnation. Details of design must not be standardised, but only ends or performance. Standards should be determined by organised effort rather than by the present costly process of trial and error, and should be done by the I.E.E. *Discussion:* **R. E. Crompton** did not think that absence of standardisation had done much harm up to the present. The small variety of pressures shown in the author's table proves that consulting engineers have not varied very much. Small motors of one-third and one-sixth H.P. are already being standardised, and this will occur increasingly

with larger sizes suited to tools taking a definite amount of power. **J. Slater Lewis** remarked that establishment charges on a machine would fall 60 per cent. if only one type were made. The charges are higher on electrical than they are on any other machinery in this country. Our shops should be standardised. **J. S. Raworth** remarked that pressure and periodicity are analogous to gauge in a railway. In this, the governing factor, consulting engineers have come much nearer Mr. Sellon's standard than he imagines. The standardisation of details is far more important in effecting economy than standardisation of pressure or periodicity, and in this matter small alterations made by a draughtsman in his work are an example of the simple way in which a standard can be departed from. **M. Robinson** was of opinion that if electrical firms would attack the problem with courage, they would attain their wish. In the case of one order of a single engine for 1,200 H.P., Willans & Robinson at once expended a much larger sum than the price of the engine upon standard jigs and templates, but eventually before the first engine was out of the place eighteen others were on order, and the templates were paid for many times over. **R. Hammond** remarked that the periodicities of 83, 84, 87, 80, and 81 arose from his standard of 10,000 complete alternations per minute with slight fluctuations of engine speed. The disadvantage of a manufacturer as compared with a consultant, is that the former sees so very much of his own productions. The function of a consultant is not to aim at brilliancy, but to see that the contractor gives what he has undertaken to give. **W. B. Esson** remarked that there is neither on the Continent nor in England any great agreement as to standards between the manufactures of different firms, though there is greater agreement in particular firms. The fact is, no one firm in this country has enough of any one class of machines to keep them going. No consulting engineer that he had ever known would refuse to accept a good thing from stock rather than draw up a specification for it. There are great difficulties in specifying things without to some extent defining the means by which they are to be obtained, because in providing the means the guarantee required as to the fulfilment of the ends for a long period is obtained. We are beginning at the wrong end by fixing a standard for frequency. In America, where ropes and belts are used, uniform frequency only means a change of pulley. Similarly turbines are easily altered to suit the standard dynamos insisted on. Consulting engineers have never dogmatised about frequency ; it is only the manufacturers who have done this. There is no analogy between frequency and railway gauge, and frequency is the one factor which ought not to be fixed. **L. Andrews** was of opinion that if details are not insisted on, makers must take greater responsibility. The Hastings Company is an example of how taking the advice of a company, and not of a consultant, led to anything but a standard supply station. **S. A. Russell** was of opinion that units cannot be standardised because of the various speeds of standard engines. Belt-driven plant need not be standardised. It is rather a disadvantage if all makers have exactly the same sizes. In adopting American voltages, &c., for traction, we have handicapped our own makers and our lighting stations. The rating of machines should certainly be fixed, and say a 50-kw. machine shall be one that will give 50 kilowatts continuously for a certain number of hours. **L. Birks** gave tables of periodicities at various stations, showing that we are rapidly deciding on 50 periods. M. O'G.

1928. *Causes of Healing in Metal Bearings.* **R. Job.** (Mech. Eng. 5. pp. 818–819, June 9, 1900. Abstract of an article in the American Engineer and

Railroad Journal.)—The author draws attention to the fact that it is well known that physical condition and structure have a great influence upon the wear of the metal in a bearing. Generally great care is taken to ensure the correct chemical composition and little attention is paid to the conditions under which the finished shape of the metal is produced in the foundry.

The old copper-tin alloy of seven to one has been found to be inferior as a bearing metal, and a copper-lead-tin composition introduced. The efficiency is found to increase with the proportion of lead present, though this cannot exceed 15 per cent. in practice.

Tests of a large number of bearings which had run hot and had been removed from the carriages of the Philadelphia and Reading railway are referred to. The causes of excessive heating indicated by an examination of the results of these tests may be summarised as follows: (1) Segregation of the metals. (2) Coarse crystalline structure. (3) Dross or oxidation products and an excessive amount of enclosed gas in the metal.

Want of proper lubrication may, of course, be also mentioned, but this cause accounted for but a small percentage of the bearings examined.

Segregation is found to be due in many cases to an attempt to alloy the metals in improper proportions, notably in the case of copper-tin-lead compositions, in which it has been sought to introduce an excessive proportion of lead. To some extent segregation can be prevented by the use of a cold mould, but then the ductility is decreased, with the result of rapid wear in service.

The coarsely crystalline structure is found to be due to the presence of antimony in the alloy, but more frequently to the practice of rapid pouring at high temperatures. It is also caused by the presence in excess of deoxydising agents. The effects of crystallisation upon the bearing are twofold. In the first place, increased local heating results owing to the varying degrees of hardness and heating capacity of the constituents, and secondly, the ductility and tensile strength are materially decreased.

The presence of dross is simply a proof of carelessness in the foundry. Excess of enclosed gas may be due to insufficiency of deoxydising agents or to pouring at too low a temperature.

Increase of strength and ductility is found in all cases to be synonymous with better wear. An instance is cited of two bearings practically of the same composition, one set giving on test a tensile strength of 16,500 lbs. per square inch and elongation of 6 per cent., and the other giving 24,000 lbs. per square inch tensile strength and 13 per cent. elongation, the difference being attributable to the porosity of one and homogeneity of the other. It was found that the first-named set had worn 35 per cent. more in the same time than the second set. E. C. S.

1929. *Power required for Heavy Machine Tools.* (Engineer, 89. pp. 304–306, March 23, 1900.)—With all tools, except grinding machines, the power required at the Atlas Works, Sheffield, was obtained by direct experiment with a portable motor. In the case of grinding machines, these experiments could only show the power that caused the belt to slip, not the maximum that could be usefully employed on the shaft of the grinding disc. Experiment shows that it is certainly not less than 40 H.P., and possibly much more. Planing machines are the least well adapted to electric driving owing to the momentum to be absorbed and reinitiated in a contrary direction. It was not found feasible to run the separate motors driving the planing machines in parallel. Until this can be done it would seem better to run not less than

three machines from one motor. The small amount of oil used by roller bearings is much in their favour, but a more lengthened experience of them is desirable. A double-screw planing machine 14 ft. 8 in. between the standards, cutting speed 10½ feet per minute, took 25½ H.P. at the start and 18 during the stroke. A 3-inch spindle double radial-arm drilling machine, drilling two holes ⅞ inches diameter, took 1½ H.P. A side planing or ripping machine (pair of saddles driven by screw), holding 1 inch ploughing tools, one cutting and one returning, speed 9 ft. 9 in. per minute, took on a heavy cut at a maximum of 4½ H.P. A very large slotting machine, cutting tool 1¼ inch wide, feed 1/16 inch on very tough material, took on the return stroke against the weight of the tool arm a momentary 15 H.P. and 10½ maximum during stroke. Recording ammeter readings are reproduced.

M. O'G.

1930. *Electric Power in Factories.* **G. H. Bowden.** (Elect. Engin. 25. pp. 591–593, April 27, and 633–637, May 4, 1900. Paper read before the Glasgow University Engineering Society.)—It is economical to provide cables for extension, whereas this cannot be done with steam pipes with economy. A complete transition to electric driving can be made in any factory without stopping the work. The results obtained in various important works are reviewed. The capital expenditure at Dorman and Long's was £8,000 and the saving at the rate of £4,000 a year. At Furness Withy the output has been doubled, yet the working cost is less than before. Every machine in a shipyard can be electrically driven except the steam hammers. The following table is given of the power absorbed by shipyard tools :—

	E.H.P.
Double punch, running light	2·0
Punching both ends 1 in. hole, ⅞ in. plate, 28 punches per minute at each end	5·0
Punch and shear, running light	2·0
Punching hole as above, and shearing ⅞ in. plate, 5½ in. cut, 28 strokes per minute	6·5
Large plate-bending rolls, running light	5·5
Rolling plate 9/16 in. thick, 4 ft. 4 in. wide, and 16 ft. 6 in. long, endways on (4 ft. 4 in.)	6·9
Sideways on (16 ft. 6 in.)	12·2
Plate 11/16 in. by 4 ft. 8½ in. by 21 ft. long, sideways on	19·3
Same rolls lifting and lowering top roll : Lifting	8·5
Lowering	7·0
Forcing 11/16 in. plate down	10·0
Forge fan, for 24 fires	10·5
Angle squeezer, running light	0·8
Squeezing	2·5
Wood-working machinery. Small plane	0·8
Tenoning machine	0·8
Band saw	1·5
Cross-cut saw	2·5
Small circular saw cutting 6 in. pitch-pine hand-fed	6·4
Circular saw 48 in. sawing 18 in. teak, 6 ft. 6 in. per minute	24·0
Sawing 4½ ft. teak, 25 ft. per minute	17·7
Countersinking machine. Actual power taken in countersinking	3·5

	E.H.P.
Riveting machine, running light	1·6
Riveting	3·0
Wall planer, taking $\frac{3}{8}$ in. cut, cast iron	5·0
Radial drill, drilling $1\frac{1}{16}$ in. hole, cast iron	1·59
Plate planing machine, running light	0·6
Reversing light	1·8
Cutting 1 in. by 14 ft. plate	3·1
Stern frame, boring, cutting	1·75
Shafting lathe 18 in. centre, running light	0·5
One tool cutting $\frac{1}{16}$th in. square cut	1·8
Two " " "	2·5
Lathe 9 in. centre, $\frac{3}{16}$th in. cut	0·6
Angle-cutting machine, running light	1·6
Cutting angle 6 in. by $3\frac{1}{2}$ in. by $\frac{1}{2}$ in.	3·5
Winch, lifting 28 cwt. single purchase, 50 ft. per minute	6·5
Ending machine, running light	1·9
Cutting girder 18 in. by 7 in.	4 to 4·8
Cold saw, running light 24 in. saw	2·0
Cutting 4 in. by 4 in. angle	4 to 4·5
Air compressor, 10 in. by 14 in. cylinder, 50 lbs. pressure	15 to 23·5
Portable drill, when drilling 1 in. hole	1.5
Hydraulic pumps, three pumps, $3\frac{3}{4}$ in. diameter; $4\frac{3}{4}$ in. stroke, 60 strokes per minute; pressure, 870 lbs.	38·0
Joiners' shop motor, normal load	14·8 to 22
Machines being driven from this motor: One 20 in. plane, one circular saw 24 in., one 30 in. planing and sand-paper machine	
Electric winch, running light	1·2
Lifting 24 cwt. 16 ft. per minute	5·6

Drawings are given of an enclosed motor with flexible shaft, an electric centrifugal pump, drill, and a travelling crane. The first cost of a polyphase system is greater than that of a continuous current. Difficulties also come in where the motor has to be constantly reversed or the speed varied. Greater margin must be allowed in the powers, so that the cost of application is nearly double that of continuous current. M. O'G.

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1931. *Berrenberg's Air-pump for Lamp Manufacture.* (Elektrotechn. Zeitschr. 21. pp. 214–219, March 15, 1900.)—This article gives a full description of the Berrenberg mechanical air-pump (see 1900, Abstract No. 418), illustrated by a photograph and a number of detail drawings. C. K. F.

1932. *Starting Resistance for Continuous-Current Motors.* **R. Krause.** (Elektrotechn. Zeitschr. 21. pp. 328–329, April 26, 1900.)—A method of calculating the resistances so that the motor shall start evenly and without sparking at the commutator, the section of the wire being also arranged to carry the varying currents without overheating. E. K. S.

1933. *Wiring.* **C. E. Knox.** (Amer. Electn. 11. pp. 479–481, and p. 529, 1899; 12. pp. 42–45, Jan., 91–92, Feb., and 142–143, March, 1900.)—Description of Outlet boxes (pp. 479–481), Cut-out cabinets (p. 529), Panel boards (pp. 42–45), and Switchboard design (pp. 91–92 and 142–143).

GENERATORS, MOTORS, AND TRANSFORMERS.

1934. *Helios Co's. Three-phase and Single-phase Alternator at the Paris Exhibition.* (Elektrotechn. Zeitschr. 21. 499–502, June 21, 1900.)—This machine forms one of the four large generating sets in the German section of the electricity building. It is capable of giving either 2,000 kw. on a single-phase circuit, or 1,200 kw. on a single phase, and 1,500 kw. on a three-phase circuit, at 50 periods, when running at 70 revs. per minute, number of poles, 84. A line drawing and four photos are given showing the construction of the machinery, also particulars of the energy stored in the flywheel. E. K. S.

1935. *Magnetic Leakage in Inductor Alternators.* **C. F. Guilbert.** (Ind. Élect. 9. pp. 255–258, June 25, 1900.)—The effect of magnetic leakage is more important in inductor alternators than with ordinary alternators, as the magnetic flux in the armature of the former does not reverse in direction, but merely oscillates between a maximum and minimum value both of the same sign. If we assume that when the flux is a maximum the iron circuit of two inductor poles is bounded on the inside by three sides of a square of length t, the other side being moved parallel to itself through a distance d equal to the air gap, and if we suppose that the breadth of the poles, which are rectangular in section, be also t, and that the wheel is so large that we can neglect its curvature, then

$$\eta = \frac{\text{lost flux}}{\text{useful flux}}$$

$$= \frac{d}{t}\left[\frac{4}{\pi}\left\{\log_e\left(\frac{\pi t}{2d}+1\right)+\frac{t}{\mu d}\right\}+\left(1+\frac{t}{\mu d}\right)\frac{t}{t+d}\right]$$

With the inductions used in practice, μ the permeability is about 80. The author gives the following practical example. For an Oerlikon inductor alternator of 800 kilowatts—

$$t = 23{\cdot}5,\ d = 0{\cdot}5 \text{ and } \mu = 90.$$

Substituting these values in the formula, we get

$$\eta = \frac{0{\cdot}5}{23{\cdot}5}\left\{1{\cdot}27(4{\cdot}3 + 0{\cdot}52) + 1{\cdot}52\frac{23{\cdot}5}{24}\right\}$$

$$= 0{\cdot}16$$

The true value of η found experimentally was 0·15. The author's approximate formula always gives results slightly in excess of the true values of the leakage. He, however, in this paper gives accurate formulæ, taking into account the curvature of the inductor wheel, &c. He states that Kapp's formula,

$$\eta = 1{\cdot}7\frac{d}{l}\log_e\frac{t}{2d}$$

always gives results much too small. For example, using Kapp's formula to find η in the above case, we find $\eta = 0{\cdot}114$. A. R.

1936. *Synchroniser for Rotary Converters.* **F. W. Springer.** (Elect. World and Engineer, 35. pp. 944–945, June 23, 1900.)—The author describes a device invented by J. Pearson, of Minneapolis, by means of which rotary converters can be speeded up and put in circuit without any special skill being required on the part of the operator. The ordinary method is to run the converter as a motor from the direct current side, one switch of the three-phase circuit being closed. When the synchronising lamps across one of the other three-phase switches show that it is running in synchronism with the generators, then the remaining two three-phase switches are closed. The author states that, unless this be very carefully done, disastrous results may ensue. It is found advisable in practice to cut off the direct current from the converter at the instant the connection with the alternating circuit is completed, in order to avoid the risk of the conflicting direct and alternating current effects throwing it out of step. Pearson's device does this automatically. It is in use in all the power houses of the Twin City Rapid Transit Company, Minneapolis, and has been in daily use for over a year to put a 750 kw. rotary in circuit. A. R.

1937. *Alternating Current Induction Motors (especially Heyland Motors).* **A. C. Eborall.** (Inst. Elect. Engin., Journ. 29. pp. 799–836; Discussion, pp. 836–856, July, 1900.)—This is a comprehensive paper on the design of induction motors, in which the author gives particular attention to the starting devices of monophase motors, special stress being laid upon the Heyland method.

The Heyland method of starting monophase motors consists in winding the starting stator-coil with comparatively few turns in such a way as to produce large magnetic leakage, while the running-coil has many turns with as small magnetic leakage as possible. The rotor has a tri-phase star winding connected to three slip rings, by means of which resistance may be inserted till full speed is attained. The large leakage of the starting-coil causes a lag between the current therein and the potential difference between its terminals. A difference of phase thus exists between the currents in the running and starting-coils, and a rotating magnetic field results.

The Heyland motors standardised for circuits of forty, fifty, and sixty cycles are designed in three ways, as follows: (*a*) To start without load. Under these circumstances the starting-current does not exceed four-fifths of the full-load working-current. (*b*) To start with two-thirds the full-load torque. Under these circumstances the starting-current does not exceed $1\frac{1}{2}$ times the full-load working-current. (*c*) To start with full-load torque. Under these circumstances the starting-current does not exceed twice the full-load working-current.

Methods of winding are given by which the speed of the motor may be altered to half or quarter the maximum speed. In the discussion the want of a good frequency-changer was emphasised. [See also Abstract No. 348 (1900).] W. G. R.

1938. *Theory of Single-phase Motor.* **F. Eichberg.** (Elektrotechn. Zeitschr. 21. pp. 484–487, June 14, 1900.)—In order to explain the action of a single-phase motor, the device of substituting two oppositely rotating fields for the simple alternating field has been frequently employed. Although this substitution is perfectly legitimate so long as the rotor is at rest, it ceases to hold good when rotation takes place, and in the neighbourhood of the speed of synchronism the motor is known to behave as

if there were only one rotating field. Hence, in his recent paper on this subject, Steinmetz (Elektrotechn. Zeitschr. 1899, Heft 25 and 26) has abandoned this device, and has deduced the equations of the single-phase motor by assuming a cross-field whose intensity is proportional to the rotor speed. In reality, the cross-field is not simply proportional to, but is a complicated function of, the speed. The author develops a simple and elegant theory of the single-phase motor by assuming the single-phase winding split up into two equal parts, and each part connected in series with one-half of an imaginary winding producing a cross-field, the two halves of this latter winding being assumed to convey currents in opposite directions, so as to produce no resultant magnetic effect. [This device has already received notice in Abstract No. 753 (1899).] Each half of the actual single-phase winding, together with one-half of the imaginary winding producing the cross-field, constitutes a complete polyphase winding; but the two polyphase windings give rise to oppositely rotating fields. These two windings are assumed to be connected in series across the mains, and the distribution of P.D. is determined by the same laws as those governing the distribution of P.D. between two transformers connected in series. When rotation takes place, the effective impedance of the polyphase winding producing the field in the direction of rotation is increased, while that of the other winding is decreased. Making use of these considerations, the author explains in detail the working of a single-phase motor. The paper is illustrated by a number of diagrams. A. H.

1939. *Testing Induction Motors.* **M. Breslauer.** (Elektrotechn. Zeitschr. 21. pp. 469–474; Discussion pp. 474–475, June 7, and p. 516, June 21, 1900. Paper read before the Elektrotechnischer Verein, March 27, 1900.)—After briefly explaining the induction motor diagram first given by Heyland in 1896, and recently corrected by him so as to eliminate the errors contained in the original diagram, the author applies the corrected diagram to deduce a number of important relations connecting the various quantities which occur in the study of induction motors. The corrected diagram is shown in Fig. 1, in which A B $= i_m =$ magnetising current (*i.e.*, current taken at speed of synchronism, neglecting losses); A C $= i_s =$ short-circuit current (*i.e.*, current taken by short-circuited rotor when at rest); A D $= i_1 =$ primary current; E D $= i_2 =$ secondary current; A E $=$ magnetising current corresponding to the primary current A D. If i_w and i_o stand for the load and wattless components respectively of i_1, $\tau = \frac{i_m}{i_s}$ for the leakage factor, and $\cos\phi$ for the power-factor, then

$$\tau = \frac{i_m(i_o - i_m)}{i_w^2 + i_o(i_o - i_m)}$$

$$\cos\phi = \sqrt{\frac{(i_m - \tau i_o)(i_o - i_m)}{i_m\{i_o(1+\tau) - i_m\}}}$$

$$i_2 = \sqrt{\frac{1}{\tau(1-\tau)}} \cdot \sqrt{i_m(i_o - i_m)}$$

$$i_w = \frac{1-\tau}{2\tau} i_m$$

The most interesting deductions from these equations are: (1) The greatest overload which the motor is capable of standing is directly propor-

tional to i_m, and since i_m may be varied by altering the number of turns, the point of maximum overload may be controlled by this means; (2) the maximum power-factor is independent of i_m, and depends solely on the leakage factor τ. The diagram, Fig. 1, is based on the suppositions of (*a*) pure sine waves of E.M.F., current and induction; (*b*) proportionality between the exciting current and magnetic induction; (*c*) absence of all losses in motor. The author next considers how the diagram must be modified in order to render it applicable to ordinary conditions of working. As regards (*a*), we know that in other alternating-current problems this supposition leads to results which are sufficiently accurate for practical purposes; (*b*) is practically correct for the vast majority of induction motors within the working limits. As regards (*c*), we have to consider: (α) the heat-loss in the primary winding; (β) the hysteresis and eddy-current losses in the primary core; (γ) the heat-loss in the secondary winding; (δ) the bearing and air-friction losses. The losses (α) and (β) might, so far as the diagram is concerned, be supposed to take place outside the motor, and might be represented by a simple resistance connected in series with the motor. The drop occasioned

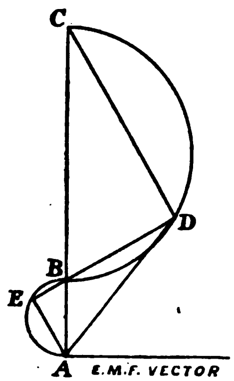


FIG. 1.

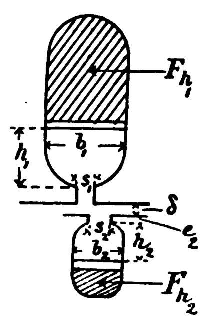


FIG. 2.

by this imaginary resistance would then be taken into account before constructing the diagram. With regard to (γ) and (δ), these may be regarded as an additional load on the motor-pulley. Due allowance being made for the losses, the author proposes the following method of testing induction motors. The motor running light, two curves are determined, connecting the primary P.D. with (1) the magnetising current i_m (this will, as a rule, give a straight line up to the working limit), and (2) the power absorbed by the motor. The rotor is next rigidly clamped and short-circuited through an ammeter, and two further curves are obtained, connecting the primary P.D. with (3) the short-circuit current and (4) the power taken by the motor. Finally, the resistance of the primary is measured. From the data so obtained the behaviour of the motor may be completely determined *without the necessity of any brake tests.* By producing the curve (2) backwards the frictional loss may be separated from the hysteresis and eddy-current losses. The Heyland diagram and the equations deducible therefrom may then be used for calculating the leakage factor, and for constructing curves connecting the load on the motor with efficiency, power-factor and slip.

The author has carefully tested the method in practice, and gives curves showing that the results of brake tests closely agree with the curves deduced by the above method. He next considers the effect of the air-gap and length of polar arc on the value of τ, and arrives at the conclusion that in order to make τ as small as possible, it is desirable to make the motor of large diameter and relatively narrow width; actual measurements of τ appear to point to the fact that the inactive portions of the windings contribute considerably towards magnetic leakage.

In the discussion, **Görges** pointed out that the value of τ depends very largely on the number of slots, and decreases as this number is increased. **Niethammer** contributed the following formula for the primary leakage-field L_1, which he has found to give results closely agreeing with those of actual measurements:—

$$L_1 = K \frac{i_1 Z_1 l}{p q_1} \left\{ \int \frac{F_{h1}\, dh_1}{F_1 b_1} + \frac{e_1}{s_1} + \frac{\delta}{s_1 + 1{\cdot}68} + \frac{1}{\frac{28}{\tau_z} + \frac{s_2 q_2}{e_2 q_1}} + \frac{1}{\frac{28}{\tau_z} + \frac{q_2}{q_1 \int \frac{F_{h2}\, dh_2}{F_2 b_2}}} \right\}$$

where the meanings of most of the symbols are given by Fig. 2. K is a coefficient whose value ranges from 1 to 1·1; Z_1 is the total number of primary conductors; l the length of the motor; $2p$ the number of poles; q the number of slots per pole per phase; F_1 the entire slot area; τ_z the length of the crown of a tooth. The secondary leakage-field is obtained by interchanging the suffixes 1 and 2. A. H.

1940. *Eddy Current Losses in Transformers.* **F. Townsend.** (Amer. Inst. Elect. Engin., Trans. 17. pp. 233–243, April, 1900.)—Experimental results are quoted to show that the eddy-current loss in a transformer may be written in the form $kB^{1{\cdot}6}f^2$, where k is a constant, B the maximum induction density in the core, and f the frequency. If this were true it follows that the total core loss W would be given by the equation

$$W = B^{1{\cdot}6}\,(k_1 f + k_2 f^2)$$

where the first term represents the hysteresis loss and the second term the eddy-current loss. The ratio of these two losses would also be equal to $\frac{k_1}{k_2 f}$, and would be independent of the magnetisation. The author analyses some experimental results obtained by W. Peukert, and published in the *Elektrotechnische Zeitschrift* of September 21, 1899 [see Abstract No. 204 (1900)], on iron losses in a transformer, and concludes that the agreement between these results and results calculated on the above hypothesis, are as close as the experiments warrant. A. R.

1941. *Excitation of a Two-phase Rotary Converter at Various Loads.* **E. Wilson.** (Electrician 45. p. 512, July 27, 1900.)—The author quotes experiments of Parshall and Hobart on a three-phase rotary converter, in which they found that the excitation of the converter at full load was about 15 per cent. greater than at no load. He made a similar experiment on a two-phase generator, and found that the excitation was practically constant at all loads. The converter was connected to the two-phase generator by four short conductors, and the excitations of the two machines were so adjusted that the volts across the slip-rings of the generator were nearly

constant at all loads, and at the same time the power-factor of the converter circuit was a maximum. The following are some of the experimental results :—

Revs. per min.	Generator.		Watts delivered.	Power Factor of Converter.	Direct Current.		Exciting Current.	
	Volts per phase.	Amperes per phase.			Volts.	Watts.	Generator.	Converter.
812	82·2	4·28	350·8	0·998	115·2	0	3·00	3·20
815	81·7	30·96	2520	0·99	113·7	4298	3·29	3·19
813	82·1	56·5	4613	0·99	113·5	8240	3·34	3·14

The exciting current of the converter was thus about 2 per cent. less at full load than at no load. A. R.

REFERENCES.

1942. *Dynamo Electric Machinery.* **C. F. Guilbert.** (Écl. Électr. 22. pp. 166–171, Feb. 3, 250–256, Feb. 17, and 449–456, March 24, 1900.)—Recent patented improvements, chiefly in connection with transformers (pp. 166–171), motors and dynamos.

1943. *Weight of Dynamos.* **E. Rosenberg.** (Zeitschr. Elektrotechn., Wien, 18. pp. 165–167, April 1, 173–178, April 8, and 197–201, April 22, 1900. Paper read before the Elektrotechnischen Verein, Jan. 3, 1900.)—An analysis of the various conditions which give minimum weights of copper and iron, for a given output, in the various types of continuous-current dynamos. The paper is mainly mathematical, but some interesting curves are given. E. K. S.

1944. *R[illegible]verters.* **A. Moens.** (Assoc. Ing. Él. Liège, Bull. 11. pp. 110–136, April [illegible], 190[illegible].)—The writings of Steinmetz, Kapp, Thompson, Parshall, and others on the su[illegible]ject of rotatory converters, are reviewed. Interesting notes are given on the subjects of "hunting," frequency, regulation of voltages, armature reaction, &c., and there is a short bibliography at the end of the paper. E. K. S.

1945. *Effect of Line on Working of Synchronous Motors.* **F. Eichberg.** (Zeitschr. Elektrotechn., Wien, 18. pp. 183–184, April 8, 1900.)—A brief abstract of a paper on the above subject. A. H.

ELECTRICAL DISTRIBUTION, TRACTION, AND LIGHTING.

ELECTRICAL DISTRIBUTION.

1946. *Mutual Inductance of Three-phase Circuits.* **A. J. Bowie, Jun.** (Elect. World and Engineer, 35. pp. 939–944, June 23, 1900.)—A very complete discussion of the problem of the mutual induction between the six wires in two overhead three-phase systems of mains is given. The author first of all discusses the magnitude of the effects produced by mutual induction, and then indicates various methods of spiralling the wires, by which these effects can be made negligible, or even altogether eliminated. For example, if the mains forming each circuit be connected to the insulators on the poles in such a way that the mains of each system form a spiral, but the pitch of one spiral is three times that of the other, then the mutual induction will be zero. This is entirely independent of any balance of the loads. The author points out that the ordinary method of making each three-phase system into a spiral, one right-handed and the other left-handed, does not eliminate mutual induction, which produces an unsymmetrical effect on the voltage triangle. In this case, if we interchange two of the wires in one circuit the effect is made symmetrical. In the author's opinion, the more we can avoid the necessity of spiralling the wires the better and simpler will be the system. Hence he gives several solutions in which, although mutual induction has not been altogether avoided, yet spiralling is reduced to a minimum. [See also Abstract No. 928 (1900.)] A. R.

1947. *Limitations of Long-distance Power Transmission.* **W. E. Goldsborough.** (Elect. Rev. N.Y. 36. p. 391, April 18, 1900.)—This article deals with the various factors governing the economy of long-distance lines with extra high-pressure, and the difficulties which are encountered in such work; for example, surface leakage, leakage between conductors when pressures of over 60,000 volts are used, and charging current. The author deals with the question rather fully, and arrives at the conclusion that power can be transmitted to a distance of 500 miles from the generating station with financially good results. E. D. P.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

1948. *Prague Electricity Works.* **E. Kolben.** (Elektrotechn. Zeitschr. 21. pp. 520–528, June 28, 1900.)—This is the first three-phase alternate current central station from which current is supplied from the same 'bus bars for tramways, for power, and for lighting. Current has to be carried to some parts of the town which are nearly five miles distant from the generating station, and for arc lamps, for public lighting, and for tramways continuous current at 600 volts has to be supplied. The general principle upon which the plant is designed is that of a central generating station with substations in which rotary converters are erected. Current is generated at the central station at 3,000 volts pressure, three-phase alternating. Thence it is taken through high-pressure primary circuits to various points where the voltage is reduced by transformers to 123 volts for domestic lighting. A portion of the

high-pressure current goes to rotary converter substations and is converted into continuous current at 500 to 600 volts. Continuous current at this pressure is also generated at the central station for feeding the tramway conductors near the station.

The feed-water for the boilers is taken direct from the Moldan and passes through suitable filtering apparatus capable of cleansing between 9,000 and 10,000 gallons per hour, which capacity can be doubled by enlarging the filter. Thirty-two boilers are installed, each having about 2,300 square feet of heating surface. The boilers are divided into groups of eight, each group having its own chimney, which is 220 feet high and 9 feet 9 inches internal diameter at the top. Each boiler is provided with a superheater, which—it is stated—brings up the temperature of the steam in the main steampipe to between 300° and 340° C. (572° to 640° F.). The boilers work at about 180 lbs., and, presumably, natural draught only is used. Mechanical stokers are provided, and the coal is brought to them by means of conveyers, worked by electricity, capable of moving half a ton in nine seconds.

The engine-house is designed for the reception of five three-phase alternating units of about 1,000 H.P. each and five of about 2,000 H.P. each, besides some smaller continuous current units. The large engines are triple expansion of a somewhat special type.

The method of driving the exciter is novel. The armature of the alternator is mounted direct upon the main shaft of the engine, and the exciter is driven by a toothed wheel, also fixed upon the engine shaft, and pinion geared 4 to 1. The flywheel armature is weighted so as to admit of a coefficient of unsteadiness of $\frac{1}{340}$. Diagrams shown in the original paper indicate the successful achievement of this. Illustrations are given of the larger units and of the rotary converters, and diagrams of the switchboard arrangements at the central station and substations, showing how the accumulator batteries are employed in the ordinary course of operating the plant. The chief point of interest is the adoption of the same periodicity for lighting as well as for power. E. C. S.

1949. *Electricity Works at La Praz (Savoy).* **A. Laponche.** (Génie Civil, 37. pp. 128–131, June 23, 1900.)—This is one of the four factories of the French Electro-metallurgical Company, and is devoted to the production of aluminium, pure and in the form of alloys, calcium carbide, &c. It is situated on the left bank of the river Arc, near the Mont Cenis railway, and power is taken from the river by two steel conduits, 2 metres and 2·4 metres in diameter, 1,200 and 1,000 metres long, and with falls of 33 and 72 metres. The plant has a total capacity of 12,500 H.P., and consists for the most part of Thury dynamos (3,000 amperes, 130 volts) driven by Girard turbines. There are also various other dynamos of voltages ranging from 120 down to 40, two being unipolar 40-volt machines of 350 H.P. each; and two alternators of 800 H.P. and 350 H.P. The high-pressure hydraulic conduit transmits 10,000 H.P., the velocity of the water being 2·75 metres per second. The thickness of the steel of which it is made varies from 5 mm. at the intake to 15 mm. at the turbines. It crosses the river in the form of an arch of 50 metres span, without additional support. Some data are given as to the stresses calculated for this arch when full of water. The plant commenced working in January, 1898. W. H. E.

1950. *Dublin Electric Tramways.* (Elect. Rev. 46. pp. 658–663, April 20, 703–707, April 27, and 745–747, May 4, 1900.)—*System:* Overhead trolley, fed

by continuous current, except on the Dalkey line, which is by three-phase transmission. The *boiler-room* contains 12 Babcock and Wilcox boilers, each having 2,530 square feet heating surface; 160 lbs. working pressure. The feed-water is heated by two groups of Green's economisers in each flue, each group having 192 tubes (9 ft. × $4\frac{9}{16}$ in.). Coal is stored in overhead bunkers of 1,200 tons capacity, and is fired by Vicar's mechanical stokers, to which it is delivered through shoots. Hunt (New York) handling and conveying apparatus transports the coal from the quay to the bunkers. The *engine-room* contains five Allis cross compound vertical engines, having cylinders 20 in. and 40 in. diameter, 42 in. stroke, indicating 800 H.P. at 90 r.p.m. Fly-ball governors control the cut-off by Reynolds' Corliss trip valves on both cylinders. The guaranteed consumption at 630 B.H.P. is 12·7 lbs. steam per I.H.P. Each engine drives directly a 550-kw. G.E. 10-pole continuous current generator, giving 550 volts. The three-phase transmission in the Ringsend power station will consist of one 500-kw. generator coupled to a similar engine, and two rotary converters, each of 250 kw. output. *Feeders* of the lead-covered paper-insulated type are drawn into cement-lined sheet-iron pipes. The feeders vary in section from 0·75 to 0·2 square inch; they are divided into half-mile sections by disconnecting boxes. Distributors of from 0·3 to 0·15 square inch are of similar description, as are the return feeders, one 3,490 yards long, 2·25 square inch section consisting of three cables in parallel, and three from 2,253 to 2,536 yards long, 1·076 square inch section. The return feeders are boosted to the extent of 30 volts by three boosters of 15 kw., and one of 24 kw. capacity. The *track* is equipped on the overhead trolley system: 31 ft. iron poles, built in three sections, carry, by means of bracket arms and span wires, trolley wires of No. 0 B. and S. copper, having a breaking stress of 4,500 lbs., divided into sections of ½-mile. The double track at present completed amounts to 46½ miles, while the outlying portions will bring the total up to 50½ miles. The rails are of girder type, 92 lbs. per yard. The joints are bonded with two 000 Crown bonds and one plastic bond. The foundation of the track is a concrete bed 6 inches thick. The track is paved with granite setts grouted with coal tar and creosote. The motor cars are fitted with Peckham trucks and G.E.–58 motors. They are double-decked and have a capacity of 53 passengers. *Drawings:* Plan and elevation of power station and a map of Dublin.
J. T. R.

1951. *Norwich Electric Tramways.* (Electrician, 45. pp. 122–127, May 18, and 167–170, May 25, 1900.)—*System:* Overhead trolley. The *boiler-room* contains four Babcock-Wilcox boilers, each rated at 300 nominal H.P. and having a heating surface of 3,240 square feet; working pressure 160 lbs. The feed-water is heated by a Green's economiser. The firing is effected by Bennis mechanical stokers, to which coal is carried by Bennis conveyers. The *engine-room* contains four Browett-Lindley tandem compound 320 H.P. engines running at 200 r.p.m., capable of giving 500 H.P.; cylinders 16 in. and 26 in. diameter, 17 in. stroke. Each engine drives directly a Westinghouse multipolar railway generator developing 200 kw. at 550 volts, over-compounded for feeder drop. There is also a 15-kw. Westinghouse direct coupled dynamo for the works. The *track* is equipped on the overhead trolley system. Separate forward and return trolley wires are carried on poles by means of double brackets, single brackets, or span wires, to suit the streets, while in very narrow streets rosettes are employed. The rails are of girder type, 3 ft. 6 in. gauge, 65½ lbs. per yard, cast-welded by the Falk process. There are forty motor cars fitted with Peckham trucks, Westing-

house motors, and controllers. There are ten trailers. Both motor cars and trailers are of the double-deck type. *Drawings:* Map, scale plan of generating station, photos of works and plant, section of track, elevation of wheel-grinder, truck, rails, and plans of special work. J. T. R.

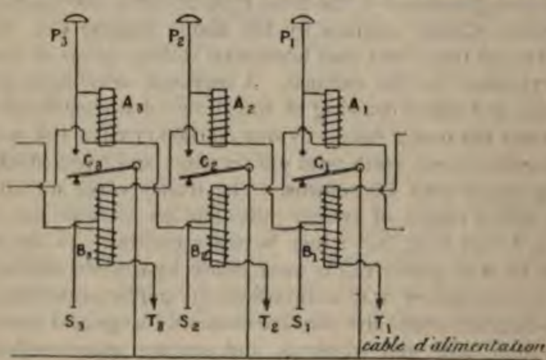
1952. *Lexington and Boston Electric Railway.* (Street Rly. Journ. 16. pp. 415–423, June, 1900.)—This road is designed to obtain part of the traffic between Boston and Lowell, a distance of thirty miles, as well as to connect the various towns along its main line, and to bid for the large amount of excursion business which is attracted by the historical interest of the points through which it passes. The *boiler-room* contains at present two 250 H.P. Caball horizontal water-tube boilers with room for four more. A railroad track runs through the boiler-room and connects with the electric line in front of the car house. Coal is stored in a 350 ton bin, over which the railroad cars can run and dump their contents without the services of a conveyer. An unusual number of heaters are included. In addition to the reheating receivers between the high and low pressure cylinders of the engines, the exhaust passes through a primary heater on its way to independent Canovery 750 H.P. jet condensers. The feed water, after passing through the primary heater, has its temperature further raised by a second heater taking the exhaust steam of the auxiliaries. The *engine-room* contains two 325 kw. General Electric generators of the usual type driven at 100 r.p.m. by horizontal cross compound Corliss engines by the Slater Engine Co., having special gridiron valves for the steam, and horizontal rolling valves of the Corliss type under the cylinders for the exhaust. A sectional drawing is given showing the valve gear, and also a drawing of the 16 feet diameter flywheel. Current is supplied from the power house by one 500,000 circular mil and one 350,000 circular mil cable going north with 4/0 returns; and two 250,000 circular mil cables going south with 4/0 returns. The trolley wires are 2/0. The line is single track with a length of twenty miles laid on chesnut ties, of steam railroad section, 7 feet long, laid 2 feet between centres. In the most popular districts a 95 lb. 9 in. girder rail is used, made by the Pennsylvania Steel Co. Almost the entire right of way is alongside the public highways. In order to attract long-distance traffic the cars are unusually large and handsome. They are 45 feet long, with ten windows, and seating accommodation for forty passengers. The motorman has a separate compartment, so that passengers may use both platforms for exit and entrance without interfering with his duties. Each car is fitted with four G.E.–67 motors, the type recently developed by the General Electric Co. to take the place of the G.E.–1,000. The improvements in this motor are: the field-poles are laminated and the armature core has ventilating spaces; the commutator is larger and longer and insulated with thinner mica to prevent sparking; the number of commutator segments has been increased to 111, but the number of slots is reduced to 37. Each car has two trolleys, one for use for running in each direction. E. K. S.

ELECTRIC TRACTION AND AUTOMOBILISM.

1953. *Willard's Sectional Third-Rail System.* (Street Rly. Journ. 16. pp. 330–331, April, 1900.)—A disused section of the Brooklyn Heights Ry. Co.'s system, a quarter of a mile in length, has been fitted up with this system for demonstration purposes and has been satisfactorily worked during the past winter. The system employs mechanical and not electrical means for cutting

the sections of third rail in and out of circuit. The third rail is of T-iron, about 17 lbs. per yard, carried on brackets and creosoted blocks every few yards, and having its top about 10 inches above the track rails. This rail is laid in 50-feet lengths with a 1½ to 2 inch gap between them. At the centre of each length is a section box containing a single throw switch with copper and carbon contacts, arranged to be closed by the movement of the third rail in either direction. Normally the switch is held off by springs, and it requires a pull of 300 or 400 lbs. on the third rail to operate it. This pull is given by the contact shoe on the car, the shoe consisting of two magnet poles separated by a brass distance piece. When the car leaves a section the springs release the switch without sparking, because the circuit through the next section is already closed. To start up on a dead section a special grip is provided on the car for sliding the third rail. E. H. C.-H.

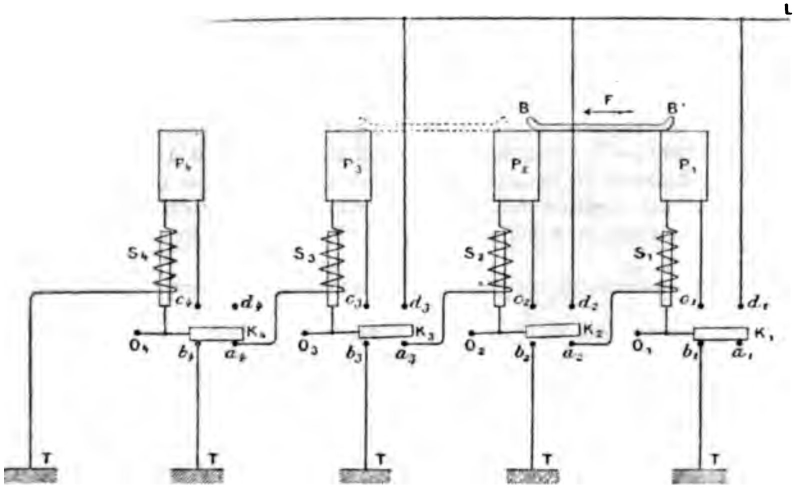
1954. *Paul's Surface Contact System.* **P. Heina.** (Écl. Électr. 23. pp. 53–57, April 14, 1900.)—This system has been installed by Schuckert on one of the Munich tram-lines, and has successfully operated for more than a year. It provides contact studs at intervals of about 4 metres (on straight lines), these plates P_1, P_2, P_3... being connected to controlling switches grouped in chambers under the road or pavement. The operation of the system is evident from the diagram of connections, where C_1, C_2... are armatures connected to



the feeder and brought into, or out of, contact with their corresponding studs P_1, P_2... by the magnets A_1, A_2... and B_1, B_2. The two windings on the magnets are for motion in opposite directions, the points T_1, T_2... and S_1, S_2 being respectively earthed and insulated or *vice versâ*, according as the car is moving from right to left or left to right. The earthing of the required points is performed by one switch for each group, this switch being operated automatically by magnets. Elaborate precautions are taken to prevent the possibility of more than two studs being alive at the same time. E. H. C.-H.

1955. *Vedovelli's Mixed Trolley and Surface-contact System.* **X. Gosselin.** (Soc. Int. Elect., Bull. 17. pp. 138–149, March, 1900.)—Æsthetic and other reasons forbade the trolley in certain sections of the Bois de Boulogne line, and a mixed system was therefore used. No halt is necessary to change from trolley to surface contact, because for a short distance at junctions both are installed, and the bow trolley avoids the difficulty experienced in putting a wheel trolley on to the wire. A diagram of connections is here reproduced. Directly the contact bar B touches the plates P_3, a shunt current traverses

the bobbin S_3, and goes to the rail through a_4 and b_4, which are joined by the armature K_4 pivotted at O_4. S_3 is thus magnetised and draws up K_3 from a_3, b_3, on to d_3, c_3, thus connecting plate P_3 direct to the main. In this way the main current is never broken at the armatures. Where two directions of motion on the same rails are required, either two independent sets of



plates must be used or a switch must be provided to reverse the connections of the solenoids. Plates are spaced at about three meter intervals, and the distributing switches are arranged in boxes holding ten, placed by the side of the track or under the footpath. If one plate fails to make contact, the one behind will remain excited until a trailing chain on the car earths the live plate and so blows the fuse and brings the car to rest. E. H. C.-H.

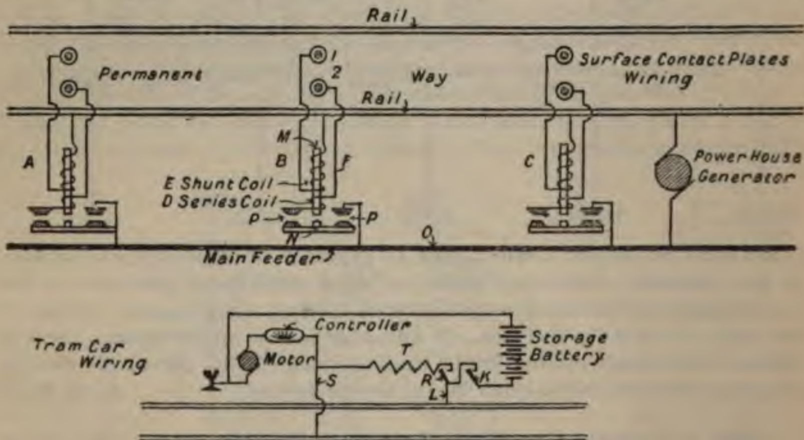
1956. *A Simplified Conduit for Tramways.* **C. Devenyns.** (Soc. Belge Élect., Bull. 17. pp. 118–127, March, 1900.)—The proposed conduit consists of a vitrified casing running along the track and having its upper surface level with the street. The main conductor is slung on insulators inside this casing and consists of a copper strip with a soft iron strip attached to its upper surface. At intervals there are soft iron plugs in the cover of the box, and at these positions there are steel contact brushes attached to the soft iron strip. The picking-up device is a series of magnets with brushes, which slide lightly over the vitrified surface of the casing until they come over the soft iron plugs, when they attract the main conductor, thereby closing the magnetic circuit and ensuring good contact. The main current is thus taken through the iron of the pick-up magnets.

The author proposes to overcome leakage by electrolysis, the products giving insulation; but the description is not clear. E. H. C.-H.

1957. *High Pressure Three-phase Current for Electric Traction.* **W. Reichel.** (Elektrotechn. Zeitschr. 21. pp. 458–461, June 7, 1900.)—An article describing experiments made since 1898 by Siemens and Halske for the purpose of studying polyphase traction, the current being collected from the trolley wires at 10,000 volts and reduced on the locomotive to a low voltage for supply to the three-phase motors. It was found that with suitable sliding contacts current could be collected at so high a speed as thirty-seven

miles an hour—about twenty-five miles an hour is the limit with the ordinary underrunning trolley. On the trial line the three-trolley wires were suspended one below the other on poles at the side of the track, current being taken off by lateral sliding contacts. Tests were made at 750, 2,000, and 10,000 volts, and it was actually found that the sliding contacts worked best at the highest pressure. Hinged contact bars which rested on the upper side of the trolley wires were given up, as not being suitable. There are eleven illustrations, including a diagram, showing the controller connections and the step-down transformers carried on the locomotive. E. K. S.

1958. *Westinghouse Surface Contact System.* (Engineer, 89. pp. 430–431, April 27, 1900.)—The essential elements of this system are (1) electromagnetic switches enclosed in moisture-proof iron cases and each permanently connected to the positive main, (2) cast iron contact plates, in pairs, placed between the rails, each pair being electrically connected to a separate switch,



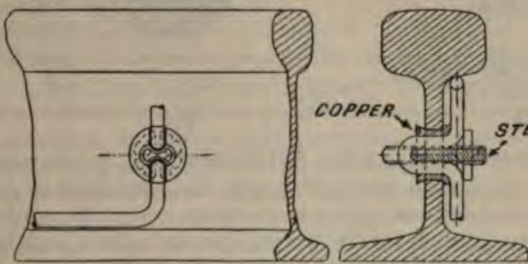
(3) metal contact shoes or bars, two of which are suspended from the underframe of each car, (4) a small storage battery on each car. The diagram of connections reproduced explains the operation of the system. The magnetic switches can be made up complete at the factory, with their pairs of contact plates carried by insulators on the switch-box casting. E. H. C.-H.

1959. *Accidents to Overhead Tramway Equipment.* **J. V. Drescher.** (Zeitschr. Elektrotechn., Wien, 18. pp. 289–293, June 10, 1900.)—An article going into the causes of breakages in overhead line material. Most of these are caused by undue wear on the trolley wire at certain points, as for instance where the wire is bent round at a splicing ear. Where possible a springy suspension is recommended. Where a tramway passes under a low bridge the trolley pole comes down to an almost horizontal position and the upward pressure is considerable. In such cases the author recommends running the trolley wires through wooden troughs having the lower sides open for the passage of the trolley wheels. E. K. S.

1960. *Electrolysis by Earth Returns.* **J. Teichmüller.** (Elektrotechn. Zeitschr. 21. pp. 436–438, May 31, 1900.)—The author reviews in detail the various methods which have from time to time been proposed and used for overcoming electrolytic troubles due to stray currents. The most satisfactory

method of dealing with this problem is that devised almost simultaneously by Kapp and Rasch, and which consists in introducing boosters into the return feeder circuits so as to maintain the feeding-points in the track at zero potential. The author gives a full description of the arrangements used at Bristol, where the method was first applied with signal success. More recently it has been used at Schöneberg, near Berlin, and in Dublin. A. H.

1961. *New Tramway Bond.* **Hecker.** (Elektrotechn. Zeitschr. 21. pp. 403–404, May 17, 1900.)—In referring to a recent paper by J. S. Edström [see Abstract No. 1612 (1900)] the author describes a bond used on the Zurich tramways. The construction is as indicated in the figure herewith, and the advantages claimed are: (*a*) Large conducting areas between the bond and the rail.



The contact area of the wire is about 400 sq. mm. and the area between the copper thimble and the rail 880 sq. mm. (*b*) By driving out the steel plug or key the bond may be used over again. (*c*) The connecting piece consists of only a plain copper wire. (*d*) The arrangement is quickly fitted, there being no soldering or amalgam to trouble with. E. K. S.

1962. *Accumulator Trials (Paris).* **A. Bainville.** (Électricien, 19. pp. 167–169, March 17, and 211–214, April 7, 1900.)—An objection to these trials is that the exact capacity of the batteries admitted to compete was not sufficiently defined. Deteriorated plates might have been replaceable as long as any of the undestroyed original plates remained. This would have lengthened the trial enormously. The method of eliminating cells is condemned as not being employed in practice, and these eliminations should have been made during fluctuating discharges. The tests have resulted in information concerning: (1) The life to be expected from a battery up to the time when the first repairs are necessary. (2) The variation of the capacity of the battery during this life. (3) The specific factors connecting weight and output, &c., of the various types. Further details of the trials are given in pp. 211–214. [See also Abstracts Nos. 403, 952, 953, and 1349 (1900).]
M. O'G.

1963. *Method of Testing Return Circuits.* **L. Nissley.** (Street Rly. Rev. 10. pp. 149–150, March, 1900.)—In a testing car the author instals the apparatus shown in the figure. Readings are preferably taken at night so as to secure uniform conditions. The method of taking readings is as follows: The car is stopped at the place where the observations are to be taken; if at a fire hydrant, the smaller cable (not shown in the figure) is put in contact with the valve of the hydrant. Now, if the Weston ammeter indicates that current is passing, the differential ammeter is switched into circuit and the current increased by the rheostats to 20 amperes. With this current flowing from the trolley to the rail and fire hydrant, the voltage is taken and simultaneously

the reading of the differential ammeter which gives the proportionate amount of current passing into rail and hydrant.

In testing bridges, viaducts, and other conductors along the lines the exploring cable is run out and attached, the differential ammeter cut out

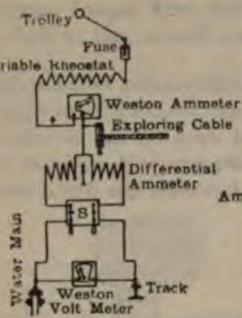


FIG. 1.

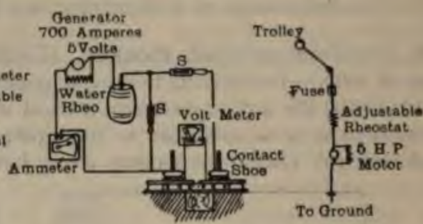


FIG. 2.

and the current increased to 500 or 600 amperes, and the drop measured. A water rheostat is used in connection with these readings to guard against the accidental burning out of the instruments. After the entire system of track has been covered by the testing car operations, and the electrical survey finished, the results should be reduced to graphic form. E. H. C.-H.

ELECTRIC LAMPS AND LIGHTING.

1964. *Incandescent Lamps.* **F. W. Willcox.** (Frank. Inst., Journ. 149. pp. 282–298, April, 353–369, May, 419–427; Discussion, pp. 427–439, June, 1900.)—This paper treats of the improvements in manufacturing and testing glow lamps up to the present time. There is nothing novel with the exception of a clever method of graphically representing the results of an initial test of a batch of lamps of the same candle power and efficiency. It is called the target diagram method. By plotting the candle power as ordinates and the watts as abscissæ, we have a graphic means of delineating accurate marksmanship (or the absence of it) in lamp manufacture. The centre of the diagram, or bull's eye, is made by the intersection of the 16 c.p. line and the 50 watt line (in the case of 16 c.p., 3·1 watt lamps). The width of the bull's eye is from the 48·5 to the 51·5 watt lines, and its depth from the 15·5 to the 16·5 c.p. lines. The corresponding dimensions of the outside of the target are from the 47 to the 53 watt lines and the 15 and 17 c.p. lines. The readings taken upon each lamp of a lot tested are plotted by placing a dot at the intersection of the corresponding watt and candle-power lines, and in this way the entire number are tested. If the lamps are good all these dots should fall within the target, and in the case of really correctly rated lamps within the bull's eye.

The author strongly advocates that lamps should be discarded when the c.p. falls to 80 per cent. of its initial value; this gives a life averaging above 400 hours for the best 3·1 watt, 100–125 volt lamps.

Discussion: **W. M. Stine** stated that the loss of candle power is due to the fact that repeated heating of the filament gradually anneals the graphitic layer of carbon formed by flashing, and brings it into a more or less amorphous state with an increased emissivity, thus lowering the temperature of the filament, and diminishing the proportion of light radiated as compared with the total energy radiated. E. C. R.

TELEGRAPHY AND TELEPHONY.

1965. *Prevention of Interception of Messages in Wireless Telegraphy.* **D. Tommasi.** (Comptes Rendus, 130. pp. 1307–1308, May 14, 1900.)—The distance at which electric waves are effective depends on the proximity of the two transmitting spheres of the oscillator. Having established communication, a second transmitter is caused to give out long and short emissions which within any zone selected will be confused with the message from the first oscillator. M. O'G.

1966. *Electrical Waves in Telegraphy.* **A. Turpain.** (Soc. Franç. Phys., Bull. 148. pp. 8–9, May 4, 1900; also Comptes Rendus, 130. pp. 1303–1305, May 14, 1900.)—Wave currents are used to speak in one direction and direct currents in the other; or intermediate stations may communicate together by direct currents on the same line as is already being used for communication between two extreme stations by wave currents. Duplex transmission and simultaneous telephony and telegraphy can also be obtained by simple means and without the use of an artificial line, thus effecting economy. To protect the insulation of the direct-current apparatus it is sufficient to enclose it in a metallic chamber. M. O'G.

1967. *Steljes Typewriting Telegraph.* (Electrician, 45. pp. 359–360, June 29, 1900.)—The features of this apparatus, as compared with the Hughes, is extreme simplicity in mechanism and action, so that it can be operated by unskilled persons. The transmitter is the ordinary A B C of Wheatstone. Upon turning the handle the armature of a simple magneto-generator is revolved and slowly alternating currents are sent to line. In the Wheatstone receiver a pointer moves to a letter on a dial corresponding to the letter in the transmitter whose key is pressed, but in the Steljes instrument a type wheel takes the place of the pointer. The escapement driving the type wheel is moved by a pair of electromagnets similar to those of a magneto-bell, the power being obtained by a weight or a spring. The type wheel is double, the rim of one disc containing thirty letters, and the other has numerals, &c. It ceases to move when the pointer on the dial of the transmitter has reached the desired letter, the current to line being at that stage automatically cut off. The type wheel is now in position to print that letter if the paper tape is brought into contact with it. The roller over which the paper passes is lifted in the following way: The line current which actuates the escapement of the type wheel also traverses a non-polarised electromagnet, and, although alternating in character, its effect upon the cores is sufficiently prolonged, while it is operating, to keep a very light armature attracted. When this drops, upon cessation of the current, it permits a cam at the end of a train of wheels to make a complete revolution. This cam, as it turns, momentarily lifts the roller and tape against the type. As the roller arm falls again a click fixed in the frame engages in a ratchet, and this turns the printing roller one space forward in readiness for the next letter. For setting all the instruments to zero there is an arm placed friction-tight on one of the wheels in the type wheel train, which is knocked down each time the printing lever is worked, so that, if the type wheels are allowed to go two or more revolutions without printing, all

the instruments will be brought to zero. There remains the device for so moving the type wheel to get letters or numerals printed, these being on the rims of different discs. A blade at right angles to the type wheel rotates with it. A light spring presses the wheel against the blade. If the zero key be depressed at the transmitter the printing lever in the receiver so influences the blade as to permit the letter band of the type wheel to print, but if the key opposite the zero key in the transmitter is depressed the blade in the receiver is pushed up, moving the type wheel forward parallel to its spindle when the numerals come into position. The apparatus has been successfully tried on circuits of various lengths and of different electrical characters.

E. O. W.

1968. *Military Telegraphs.* **P. Giron.** (Soc. Belge Élect., Bull. 17. pp. 253–261; Discussion, pp. 261–263, June, 1900.)—The author describes the modes of communication in the Belgian army and makes comparisons with those of England. The weight of the cable carried in waggons has been much reduced. It is now only 22 kg. per km. This permits of an infantry advance at the rate of 3½ km. per hour being accompanied by the telegraph. In England with very light equipment the telegraph with calvary has been run out at 12 km. per hour. Reference is chiefly made to the vibrating sounder of Cardew, with a telephone receiver, or modifications of the same. It can be worked through imperfectly insulated circuits. A case is quoted in the Soudan where it was employed on twenty-seven miles of bare wire lying upon the ground. It can also be hooked on to existing telegraph lines working on the Morse system without disturbing regular communication, a condenser or separator dividing it from the line in order to obviate a fault of derivation. Any temporary earth connection suffices. E. O. W.

1969. *Cable Signals.* **A. C. Crehore** and **G. O. Squier.** (Amer. Inst. Elect. Engin., Trans. 17. pp. 343–388, May, 1900.)—In the ordinary system of signalling through long cables a dot is transmitted by a positive current, and a dash by a negative current. During the latter portion of each impulse it is usual to connect the cable to earth. The authors replace the battery by a drum-wound alternate-current generator designed to give successive impulses of true sine form; it is provided with a third brush which connects the middle of the armature to line. An automatic transmitter, slightly modified, with brush contacts somewhat like those of the Delaney instrument, is geared to sychronism with the generator. The paper slip of the auto-transmitter has four rows of punched holes in place of the usual three; the fourth row provides for the discharge of the cable between letters and words by connecting it to earth. With this arrangement, whenever contact is established on the dot side of the transmitter-slip, a positive sinus is sent to line; similarly, when contact is made on the dash side, a negative sinus is transmitted to line; and for all intermediate spaces the cable is connected automatically to earth through the holes in the fourth line of the slip. No sounder-transmitter or earthing device is necessary. According to Kelvin's theory of cable transmission the component corresponding to the first term of the Fourier series is the only impulse appreciable at the distant end of a long cable; hence, although the generator may not send to line a current impulse of true sine form, the received current at the far end is approximately of that form. This result was demonstrated by the authors experimentally by replacing their drum-wound generator by a shuttle-wound armature. Under these conditions the *recorder* signals at the distant station approached to sine forms, and at con-

stant applied E.M.F. the amplitude diminished in more or less direct proportion to the frequency. It is apparently taken for granted that the recorder signals are truly representative of the received currents. Further, the remarkable result was arrived at that the amplitude of the received signals, working duplex, within the limits of observation with a particular recorder, for a given frequency, is more or less directly proportional to the applied volts. This result will of course require further investigation before it is accepted as general. The second part of the paper deals with the theory of the measurement of current and phase and their variations with frequency. As an example the constants for the Canso-New York cable are calculated. Comparing the E.M.F.'s employed when using a battery with those of an alternator, it is pointed out that the term "equivalent voltage" requires special interpretation. The speed of signalling is not proportional to the applied volts, but it does increase with the volts; there is an upper limit, however, which, according to the authors, depends upon the dielectric strength of the guttapercha. [The authors appear to have forgotten the lightning-protector of the cable, which in practice determines, or should determine, the upper limits of dielectric strength.] It is pointed out that, whereas for air the dielectric strength is independent of the time during which the difference of potential is applied, for guttapercha and indiarubber the time element is important. When a battery is applied to a cable without condensers, the whole pressure is upon the dielectric during the entire length of a signal, but with a sine-form generator the maximum potential is momentary, and cannot be prolonged even if desired. Hence, for equivalent voltages, conditions would appear to favour the sine form. The value of the virtual alternating potential or sine-wave E.M.F. which, applied between the sending end of a cable and earth, would produce the same maximum E.M.F. at each alternation as the maximum E.M.F. applied similarly by a battery, is 70·7 per cent. of the E.M.F. of the battery. This is true whether there are sending-condensers or not. But the fundamental component of the battery impulse has a maximum much below the maximum potential of the battery; hence, for the same maximum potential at the transmitting end of a cable, the amplitude of the wave at the receiving end is greater when a sine-wave alternator is employed than when a battery is used, and more energy is transmitted at each impulse. Moreover, the secondary components of the battery impulse introduce useless static changes which have to be got rid of between each signal. In conclusion the authors describe experiments made with the apparatus, using sending-transformers, after the manner of Dearlove. R. A.

1970. *Telephony over Telegraph Lines.* **F. Walloch.** (Elektrotechn. Zeitschr. 21. pp. 237–240, March 22, 1900. Paper read before the Elektrotechniker-Verein of Hanover, Jan. 9, 1900.)—The author describes the methods adopted for enabling simultaneous telegraph and telephone messages to be transmitted over a single line, as in the Van Rysselberghe system. All these methods depend upon the use of condensers, interposed in such a way that the slow telegraphic impulses do not affect the rapid undulations of telephony. At each station, the telephone is connected between line and earth, through a condenser; and the telegraph instrument is connected between line and earth with no condenser. In practice it is found that the capacity of each condenser need not exceed 0·2 mfd., and in place of a tin-foil "plate" condenser, it is found better to use one formed of parallel insulated wires wound together on a bobbin. For this purpose the wires may be 0·1 mm. diameter copper, double-covered with silk, each of the wires having a

resistance of about 800 ohms. Plate condensers are found to transmit more loudly but less distinctly than these wire condensers. The author suggests that loudness and clearness might possibly be both attained by combining a plate condenser with a wire condenser.

The Morse-key contacts are of carbon, so as to avoid abrupt changes of current, which would affect the telephone circuit. Or a resistance bobbin may be connected permanently between the contacts of the key. In the event of there being intermediate telegraph stations between the two stations that are to communicate by telephony, each intermediate telegraph instrument should be bridged over by a condenser ; so far as the telephone circuit is concerned, this is equivalent to cutting out the resistance of all the intermediate telegraph instruments. Further, each telegraph instrument, including the terminal instruments, should be provided with an inductive resistance of about 500 ohms, to act as a choking coil for the telephonic currents. A description is given of the application of this system to the fire-alarm service in Berlin ; by means of a portable telephone apparatus communication can be made with the central fire station from any of the 800 fire-alarm posts.

R. A.

1971. *A Telephone Experiment.* **E. Piérard.** (Électricien, 19. pp. 309–311, May 19, 1900.)—The author recapitulates the experiments referred to in Abstract No. 1226 (1900), and describes how the "singing condenser" is operated. A vibrater, before described, is put in circuit with a battery and the primary of an induction coil. In the secondary circuit is a condenser formed of sheets of tin-foil in size a square decimetre, separated by paper. When the vibrater is sung to, the condenser reproduces the melody more or less strongly according to the power of the battery. E. O. W.

1972. *Telephone Switchboards.* **J. Anizan.** (Journ. Télégraph. 24. pp. 97–102, May, 1900.)—The author describes the arrangements in force in small telephone exchanges in France where from 10 to 500 subscribers have to be provided for. There are four types of board with the usual fittings, for 10, 25, 50, and 100 lines. The first is fixed to the wall, the others stand in cabinets in the usual way. When extensions are required, another board of the same type is set up side by side with the first, and connections can be made across to the various subscribers either with the ordinary cords and plugs if long enough, or through the service or local jacks. There is an arrangement by which, during busy hours, the 100-line board can be worked by two operators. In all the exchanges, except for 10-line, the lines are brought first to distribution boards, furnished with carbon plate lightning protectors. The connections behind the switchboards are so made that jacks and annunciators can be withdrawn for repair or adjustment without detaching the wires. The microphone of the operator is furnished with two batteries for greater security in working, either of which can be plugged in or out by a switch. E. O. W.

1973. *Poulsen Telegraphone.* **J. Blondin.** (Écl. Électr. 23. pp. 397–408, June 16, 1900.)—This instrument differs from the phonograph in important particulars. It can transmit to a distant telephone receiver the sounds which it has registered. It can also register the sounds received from a distant telephonic transmitter. The currents to be registered are led to a small electromagnet, between the poles of which glides rapidly a wire or tape of steel. The wire may be 1 mm. in diameter, and the tape proportionately

wide, and move at a rate of 36 metres per minute. The variable magnetic field developed between the poles of the electromagnet produces a magnetisation of the wire or tape varying with the field. Each point of the wire or tape after passing the poles possesses a transversal magnetisation of which the intensity depends upon that of the telephonic current creating the field. Words spoken at the place of origin are thus inscribed upon the wire or tape. If the electromagnet is connected with a telephone receiver, and the tape or ribbon caused to pass its poles with the same speed and the same direction as before, the cores of the electromagnet are now affected by the variation in intensity of the magnetisation of the wire or tape, currents are thereby engendered in the bobbin, and the telephone reproduces the original speech. The steel wire or tape thus forms a record of any conversation. In the reproduction the metallic timbre of the phonograph is absent. An inscription can be cleaned off by exciting the electromagnet with a current of suitable strength and drawing the wire or tape between its poles. The wire or tape is then ready for further use.

Two forms of the apparatus are described at length with details and sketches of the various parts. One is for short conversations of one or two minutes, the other for longer records. Both are started automatically by currents from the distant station, and are arrested when the conversation or message is finished.

In the first instrument described the wire is wound upon a drum driven by a little electric motor. The drum is vertical. During the time of operation a little electromagnet which receives the currents, which rides upon a carriage sliding upon an upright, presses with its poles upon the wire, and during the revolution of the drum follows the winding of the wire, being carried vertically up its support. Upon arriving at the top the carriage comes into contact with a stud, opening the circuit, stopping the movement, and falling down to its original starting place. The mode of governing and attachment of the connecting wires is described, as also the way of joining up the instrument in conjunction with, or separately from, a telephone, either a transmitter or receiver.

The other instrument contains a long tape for registration of more lengthy communications. The tape is wound upon two flanged wheels revolving in the same vertical plane and opposite to each other so that the tape can pass from one to the other wheel or *vice versa* by altering the position of a little friction roller which actuates the wheels when driven by an electric motor. A relay as before receives the starting current from the distant station, and an electromagnet in the local circuit is caused to attract an armature and to put the machine in motion. The little electromagnet which communicates variation in intensity to the tape rides horizontally upon it between the two vertical tape wheels. The tape can be wound forwards or backwards, and can receive or transmit a message. The impressions can be effaced as previously described. Poulsen has devised three methods of reinforcing the sounds obtainable from the steel wires or tapes. The first is by arranging a series of electromagnets at equal intervals in a line, their lower poles being in contact with a similar number of horizontal steel wires arranged at equal distances vertically below, the points of contact being on one and the same diagonal line. The wire containing the record is made to travel along the upper poles successively of the electromagnets, at the same time all the other wires below are made to move at the same speed in the same horizontal direction, thus carrying with them by the action of their own magnets a facsimile of the original record. Although the magnets succeed each other

at equal intervals, the points of contact below on the wires are spaced also at equal diagonal distances, so for any given vibration or magnetic "stain" upon the original wires or tape, all the reproductions will arrive simultaneously in one vertical line during the travel of the wires. In such a vertical line are arranged a series of electromagnets, across the poles of each of which passes one of the wires. The receiving telephone is in circuit with this series, and the sounds are magnified to an extent corresponding to the number of magnets used.

The second plan is to stretch a wire parallel to the first, which contains or is receiving a magnetic record, to cause the first to pass successively across the upper ends of cores of a row of electromagnets, and the second to pass similarly across the lower ends. It is claimed that the original magnetic "stain" becomes deepened, by induction, upon the second wire, and that if this be now employed to reproduce a message the sounds are louder.

The third method of reinforcement of the sound is to cause the wire possessing the record to travel more quickly across the poles of the reproducing electromagnet. The inventor finds that at a speed of 30 metres per second a sound communicated originally in a low voice to the microphone is intensified to a disagreeably high degree.

In this last manner the construction of a telephonic relay is possible, for the wheel containing the wire or tape record, on receiving it from any station, can be driven at any desired speed, and by suitable arrangement of auxiliary electromagnets, can retransmit the sounds thus reinforced to another or several other stations.

Finally, two or more communications can be superposed upon one and the sâme wire or tape by connecting up and winding the inscribing electromagnets in different ways. To read off the inscriptions separately the reproducing magnets must be wound and connected appropriately. Thus duplex and multiple telephony is realised. E. O. W.

1974. *Hoar Frost on Telephone Wires.* **E. Piérard.** (Électricien, 19. pp. 232–234, April 14, 1900.)—Hoar frost may be removed by a blow, particularly from distribution centres. It is mathematically deduced that long stretches of wire are not a drawback with bronze of high tensile strength, but that with ordinary telegraph wires one hundred metres should be the normal limit. M. O.'G.

1975. *Submarine Cable-hooks.* (Électricien, 19. pp. 225–227, April 14, 1900.)—A special grappler by Rouillard avoids the usual multiple hooks, and provides one only which is kept at right angles to the sea-bottom. For rocky bottoms a centipede is employed with teeth in pairs at right angles to one another. To prevent the teeth from grasping the rock, a counter-tooth of opposite curvature is placed within each tooth, the distance between the teeth being, however, sufficient to admit the entry of the cable. M. O.'G.

REFERENCE.

1976. *Telephone Exchange.* **H. E. Hall.** (Elect. World and Engineer, 35. pp. 355–358, March 10, 1900.)—Description of Walnut Hills Exchange, Cincinatti, Common Battery System, 4-Party Line, described in outline and illustrated by diagrams. J. E. K.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

OCTOBER 1900.

GENERAL PHYSICS.

1977. *Maximum Density of Aqueous Solutions.* **L. C. de Coppet.** (Comptes Rendus, 131. p. 178, July 16, 1900.)—The lowering of the temperature of maximum density of water by the addition of 1 gramme molecule of salt dissolved in 1,000 gms. of water is found to be—

For ammonium chloride	between	7·07	and	7·26
„ lithium bromide	„	7·01	„	7·08
„ lithium iodide	„	8·17	„	8·45

R. E. B.

1978. *Desiccation of Hydrogen by Liquid Air.* **Rayleigh.** (Roy. Soc., Proc. 66. p. 334, June 9, 1900.)—No appreciable difference exists between the values of the density of hydrogen obtained when the gas is dried (1) by means of phosphoric anhydride and (2) by liquid air. T. H. P.

1979. *Double Films.* **R. Malagoli.** (N. Cimento, 11. pp. 351–353, May, 1900.)—The object of the author is the production of durable films on skeleton figures. A solution is made by dissolving 40 grammes of gelatine and 10 grammes of soap in 500 grammes of water. During the preparation care should be taken that the temperature does not exceed 80° C. The solution should be filtered if necessary. It is best used at a temperature of from 30° to 33° C. in a room whose temperature is not above 20° C. The films are obtained by dipping the skeletons into the solutions. Twelve hours are required to dry them. They are not thin enough to show interference colours. They may be strengthened with thin collodion, or by spraying on them copal varnish diluted with turpentine. A. G.

1980. *Gasometer.* **J. Riban.** (Journ. de Physique, 9. pp. 343–347, June, 1900.)—The ordinary portable laboratory gasometer, known as Mitscherlich's, does not give a constant flow of gas, as the height of the column of liquid representing the pressure on the gas continually decreases as the flow proceeds. In a new arrangement devised by the author this inconvenience is done away with, and, further, the upper reservoir containing the water is arranged to slide up and down on three vertical supports so that its height

and hence the pressure on the gas in the gas-holder, can be varied at will; connection is made between the two vessels by means of flexible tubing. By supplying the upper reservoir with an overflow pipe it is possible to leave the apparatus at work if necessary, all night, the only change in the pressure being that due to the change of temperature of the surrounding air. The gasometer, which is fully described and illustrated in the original paper, is readily freed from all traces of air or other gas previously present and also avoids all loss of the gas employed. T. H. P.

1981. *Expansion of Cast Silica.* **H. le Chatelier.** (Comptes Rendus, 130. pp. 1703–1705, June 18, 1900.)—An expansion coefficient of 0·0000007 between 0° and 1,000° is found for silica cast in an electric furnace. The method of measurement is that of finding the difference of lengthening of two prisms, one of which is a standardised porcelain prism. Cast silica should be capable of undergoing sudden changes of temperature without rupturing. Addition of aluminium lowers the melting-point of the silica but increases the expansion. A substance with the composition $10SiO_2 . Al_2O_3 . 2Li_2O$ expands slightly more than cast silica and melts at about 1,200°. G. E. A.

1982. *Rapid Cooling of Cast Silica.* **Dufour.** (Comptes Rendus, 130. pp. 1754–1755, June 25, 1900.)—The author had confirmed the property of cast silica of resisting sudden changes of temperature, but without knowing the explanation. Tubes of cast quartz may be heated to any extent and then plunged into cold water without showing any trace of rupture. The method of making the tubes is described. [*Cf.* previous Abstract.] G. E. A.

1983. *Propagation of Explosive Waves.* **H. le Chatelier.** (Comptes Rendus, 130. pp. 1755–1758, June 25, 1900.)—The author employs the photographic method devised by him in conjunction with Berthelot to study the propagation of the explosive wave in mixtures of acetylene with oxygen or the oxides of nitrogen, and of carbon monoxide and oxygen in the proportion CO : O. In mixtures of acetylene and oxygen ignited by means of an electric spark, the speed of propagation of the flame immediately assumes a value of several hundreds of metres per second and rapidly increases to beyond 1,000. Shortly after the appearance of the flame the explosive wave, with a greater and uniform velocity, is suddenly formed. The following table contains the distances travelled by the flame before the explosive wave comes into existence, the various mixtures being exploded in a tube 10 mm. in diameter :—

$2C_2H_2 + O_2$	1 metre	$C_2H_2 + 2NO$	0·20 metre
$C_2H_2 + O_2$	0·05 ,,	$C_2H_2 + 6NO$	0·50 ,,
$C_2H_2 + 6O_2$	0·15 ,,	$C_2H_2 + 2N_2O$	1·00 ,,
$C_2H_2 + 10O_2$	0·80 ,,	$C_2H_2 + 6N_2O$	0·10 ,,

For the mixture $C_2H_2 + O_2$ the velocity of the explosive wave has its greatest value, 2,920 metres per second, the number for $C_2H_2 + 10O_2$ being 1,850. The other gaseous mixtures give similar numbers. In the case of mixtures of carbon monoxide and oxygen, the explosive wave is not formed spontaneously but can be produced by the detonation of a certain small quantity of fulminate of mercury. T. H. P.

1984. *Propagation of Waves of Condensation in Hot Gases.* **H. le Chatelier.** (Comptes Rendus, 131. pp. 30–33, July 2, 1900.)—In studying the propagation of waves of condensation in the cases of hot gases produced by the combus-

tion of explosive mixtures the author has employed a photographic process. He finds that the thickness of the wave, *i.e.*, of the zone of variable state, is in all cases very small. For slightly condensed waves the thickness is considerably less than 1 cm., and it only takes $\frac{1}{1000}$ of a second for any point in the gas to pass from one extreme state to the opposite one. For more condensed waves the thickness seems to attain 1 cm., but the author considers that in this case irradiation on the photographic plate may have increased the apparent thickness of the wave.

The explosive wave produced by the ignition of a mixture of $C_2H_2 + O_2$ was found to travel with a velocity of 2,990 mm., the wave produced by the ignition of $\frac{1}{10}$ gr. of fulminate of mercury travelled with a velocity of 2,250 mm. in the same gas, while that produced by 0·75 gr. of fulminate travelled with a velocity 2,600 mm.—a velocity which approaches, but does not equal, that of the explosive wave.

Similar experiments were made with a mixture of $CO + O_2$.

The tubes in which the gases were contained were 5 mm. in diameter and 1 metre long.

When the waves cross in the tube they suffer a diminution in velocity and also after reflection from the ends. For example—

Initial velocity	2,300
After reflection	1,350
After first crossing	1,080
After second crossing	980

W. C. O.

1985. *Approximately Simple Waves.* **Rayleigh.** (Phil. Mag. 50. pp. 135–139, July, 1900.)—The phrase, "absolutely simple waves," standing for those which do not admit of variations of phase or amplitude, *approximately* simple waves are here "defined as waves which *for a considerable succession* deviate but little from a simple train. Under this definition large changes of amplitude and frequency would not be excluded, provided only that they entered slowly enough." After touching briefly upon the case of "beats," the paper deals specially with the contrasted case, hitherto neglected, in which the amplitude remains constant, and the sole variation is one of phase. It is then shown that the vibration

$$\cos(pt - a \sin qt)$$

can be analysed into a series of cosines of pt, $(p \pm q)t$, $(p \pm 2q)t$, $(p \pm 3q)t$, &c., the coefficients being Bessel's functions of a, the maximum disturbance of phase. E. H. B.

1986. *Temperature in Mercury Mine of Idria.* **T. Scheimpflug** and **M. Holler.** (Akad. Wiss. Wien, Sitzb. 108. pp. 950–975, 1899.)—Painstaking observations have been made of the temperature in various parts of the mine. In a certain region the temperature was found to be a maximum, about 27° C. Thus from that spot the temperature diminishes in all directions, even downwards. Some excellent diagrams illustrate the results at a glance. A. G.

1987. *Seismograph with Vertical Pendulum.* **C. Viola.** (Accad. Lincei, Atti, 9. pp. 317–321, May 20, 1900.)—The author describes the working of a seismograph with vertical pendulum, and how it is supposed to trace on a horizontal paper any motion that may be communicated to the paper by the

earth, the amplitude of vibrations being magnified by levers. The pendulum is about 10 metres in length, and has a mass of 500 kgs.

The author states that the modern perfected instrument ought to be able to give the instant that the first shock occurs; but he undertakes to prove that all other motions after the first vibration are illusory. In the mathematical work which follows he proves that certain important quantities are functions of the inertia of the building or support, and are therefore unobtainable. Seismographs with double pendulums, favoured by Milne, are also criticised. A. G.

1988. *Escape of Gases from Planetary Atmospheres.* **G. Johnstone Stoney.** (Astrophys. Journ. 11. pp. 257–258, May, and 357–372, June, 1900.)—The present paper is an answer to a criticism of the work of Stoney by S. R. Cook. Stoney draws attention to the statement that Maxwell's laws cannot be applied to gases under the conditions existing at the outer limits of a planet's atmosphere, but that the numbers determined by Cook will be useful as indicating the *minimum* rate of escape for the various gases.

The paper is divided into three parts, describing respectively: (1) Molecular movements in the lower strata of the atmosphere. (2) Molecular movements in the upper strata of the atmosphere. (3) Behaviour of helium, &c., in the earth's atmosphere. The conclusions from section (3) are as follows: (*a*) Argon is not able to escape from the earth. (*b*) Helium is escaping from the earth, and therefore (*c*) Water can probably escape from the planet *Mars;* thus the polar caps of that body may be due to solid carbon dioxide. [See further Abstracts Nos. 1025 (1898), and 805 (1900).] C. P. B.

REFERENCE.

1989. *Experimental Research.* **Elihu Thomson.** (Amer. Assoc., Proc. 48. 75–90, 1899.)—Presidential address to Section B at the 1899 meeting of the American Association for the Advancement of Science.

LIGHT.

1990. *Transparency and Opacity.* **Rayleigh.** (Roy. Inst., Proc. pp. 1–4, 1899.)—One kind of opacity is due to absorption ; but the lecture dealt rather with that deficiency of transparency which depends upon irregular reflections and refractions. One of the best examples is that met with in Christiansen's experiment. Powdered glass, all from one piece and free from dirt, is placed in a bottle with parallel flat sides. In this state it is quite opaque ; but if the interstices between the fragments are filled up with a liquid mixture of bisulphide of carbon and benzole, carefully adjusted so as to be of equal refractivity with the glass, the mass becomes optically homogeneous, and therefore transparent. In consequence, however, of the different dispersive powers of the two substances, the adjustment is good for one part only of the spectrum, other parts being scattered in transmission much as if no liquid were employed, though, of course, in a less degree. The consequence is that a small source of light, backed preferably by a dark ground, is seen in its natural outlines but strongly coloured. The colour depends upon the precise composition of the liquid, and further varies with the temperature, a few degrees of warmth sufficing to cause a transition from red through yellow to green.

The lecturer discussed various arrangements of solid and liquid bodies, such as solid prisms, discs, and spheres immersed in a liquid. He finally discussed the failure of transparency which arises from the presence of particles small compared to the wave-length of light. The tints of the setting sun were illustrated by passing the light from the electric lamp through a liquid in which a precipitate of sulphur was slowly forming. The lecturer gave reasons for his opinion that the blue of the sky is not wholly, or even principally, due to particles of foreign matter. The molecules of air themselves are competent to disperse a light not greatly inferior in brightness to that which we receive from the sky. E. E. F.

1991. *Phototropy.* **J. Marckwald.** (Phys. Zeitschr. 1. pp. 147–148, 1899. Paper read before the Naturforscherversammlung at Munich.)—The author gives the name *phototropy* to cases of change produced by the action of light which is not permanent, but in which the removal of the active light rays results in the return of the substances acted upon in a longer or shorter interval of time to their original condition. A new example of this action is recorded in which the salt of an organic base named from its constitution "Chino-chinolin," exhibits the following peculiarity: If its yellow crystals are freed from water of crystallisation at 100° they become green under the action of light, but if placed in the dark return to their original yellow colour. It is the rays of short wave-length, especially the violet, which have the power of producing this change, and the rapidity of the change depends on the intensity of the light. Direct sunlight causes the change in a few seconds, diffuse daylight in some minutes. The rate of change back again to the first colour depends on temperature. A case similar to this is also described. J. J. S.

1992. *Electromagnetic Rotation of the Plane of Polarisation by Solutions of Salts and Acids.* **J. Forchheimer.** (Zeitschr. Phys. Chem. 34. pp. 20–30, July 3, 1900.)—The author gives the results of experiments on a number of salts and acids carried out to test the accuracy of Perkin's view that with regard to the electromagnetic rotation of the plane of polarisation, the behaviour of salts is analogous to that of the corresponding acids. For the sulphates examined the results are given in the following table, in which *n* represents the normality of the solution and *m* the corresponding molecular rotation.

Ammonium sulphate.		Lithium sulphate.		Sodium sulphate.		Magnesium sulphate.		Sulphuric acid.	
n	*m*	*n*	*m*	*n*	*m*	*n*	*m*	*n*	*m*
3·75	4·98	2·60	2·38	0·97	2·985	2·73	2·03	11·53	2·072
2·964	4·95	1·96	2·80	0·48	2·955	1·86	2·02	9·01	2·072
1·978	4·87	1·708	2·64			0·934	2·04	6·95	1·991
0·876	4·95	1·320	2·67					4·77	1·960
0·492	5·01	0·747	3·11					3·008	2·030
								1·002	2·196

It will be seen from these values that solutions of the sulphates of ammonium, sodium, and magnesium resemble sulphuric acid in that the molecular rotation is independent of the concentration of the solution; in the case of lithium sulphate, however, the molecular rotation shows a considerable increase as the dilution becomes greater. For hydrochloric acid and some haloid salts the results are as follows:—

Hydrochloric acid.		Lithium chloride.		Cadmium bromide.		Cadmium iodide.	
n	*m*	*n*	*m*	*n*	*m*	*n*	*m*
8·42	4·476	10·35	4·506	2·774	20·18	1·924	43·86
5·784	4·559	7·17	4·732	1·997	20·07	0·951	42·70
3·77	4·757	5·57	4·767	0·973	19·95	0·447	42·54
2·031	4·856	2·98	4·983	0·5138	20·17	0·211	42·37
1·588	4·931	1·06	4·892				
1·138	4·831						
0·523	4·746						

Here again, in the cases of hydrochloric acid, cadmium bromide, and iodide, the molecular rotation does not vary with the concentration, whilst with lithium chloride the rotation increases with the dilution; this dependency of the molecular magnetic rotation on the concentration of the solution seems to be a special property of lithium salts. The numbers obtained confirm the observation of Jahn that the molecular rotations of cadmium bromide and iodide are respectively about twice and four times as great as that of the chloride, the value for which is 11·24. T. H. P.

1993. *Ultra-violet Spark Spectra.* **F. Exner** and **E. Haschek.** (Akad. Wiss. Wien, Sitzb. 108. pp. 825–859, 1071–1121, 1123–1151, and 1252–1266, 1899.)—*Niobium.* The commercial powder (Merck) contains Ca, Ba, Sr, Si, Ta, Be, and Fe. The spectrum of the metal has been hitherto practically unknown, but by the method of fractionation and exclusion, applied to strong and weak lines alike, the authors have been able to tabulate in this paper 1,804 ultra-violet lines, nearly all occurring in the solar spectrum.

Thorium. The strong lines of thorium appear in the solar spectrum as weak lines. The purity of the element cannot be made certain, and the arc-

spectrum is as yet unknown. The number of established lines, between 8,900 and 4,700 λ reaches 2,070 (Lockyer, Phil. Trans., 1881; Lohse, Berl. Akad., 1897). The authors tabulate 688 in the ultra-violet, and believe there is no doubt that the number of lines in elements generally is a function of the atomic weights.

The spectra of silicon, beryllium, thallium, indium, cerium, lanthanum, neodymium, praseodymium, germanium, and gallium have been further studied (pp. 1071–1121).

The spectra of yttrium, erbium, and ytterbium have been mapped (pp. 1123–1151).

The following elements have been examined both in the visible and ultra-violet part of the spectra: Didymium, neodymium, praseodymium, erbium, yttrium, cerium, lanthanum, ytterbium, scandium, gadolinium, samarium (pp. 1252–1266).

[See further Abstracts Nos. 365 and 488 (1898).] S. R.

1994. *Absorption Spectra of Liquids in the Infra-Red.* **L. Puccianti.** (N. Cimento, 11. pp. 241–278, April, 1900.)—The author gives the results of measurements of the infra-red absorption bands of a number of liquid carbon compounds. The source of the rays used is a small incandescent electric lamp, the spectrometer prism being of quartz, and the intensity of the rays is measured by means of a modified form of Fox Nichols' torsion-radiometer. The compounds examined are: Benzene, toluene, ortho-, meta- and para-xylene, ethylbenzene, methyl iodide, ethyl iodide, ether, alcohol, methyl alcohol, pyridine, allyl alcohol, carbon bisulphide and carbon tetrachloride. The absorption curves show that all liquid compounds, the molecules of which contain carbon directly combined with hydrogen, present a maximum of absorption for the wave-length $1{\cdot}71\,\mu$. Further all the benzene derivatives examined have two other maxima in common, the wave-lengths being about $2{\cdot}18$ and $2{\cdot}49\,\mu$; these are probably due to the hexagonal structure of the molecule. The three isomeric xylenes exhibit absorptions almost, but not completely, identical; the curves for the three alcohols are also very similar. [See also Abstract No. 1646 (1900).] T. H. P.

1995. *Becquerel Rays.* **J. Elster.** (Deutsch. Phys. Gesell., Verh. 2. 1. pp. 5–8, 1900.)—Magnetic deviation of polonium rays is produced in a vacuum, and seems to be more than the deviation undergone by radium rays under the same conditions. Radium preparations contain an active volatile constituent. The effect of heating active barium bromide for twenty-four hours in a vacuum in a hard glass tube is to cause a temporary weakening of its activity which is almost quite recovered in a few days. If a trace of some radio-active substance is vaporised on a platinum wire in a bunsen flame the surrounding air becomes more capable of dissipating an electric charge.

G. E. A.

1996. *Radiation of a Black Body.* **M. Thiesen.** (Deutsch. Phys. Gesell., Verh. 2. 5. pp. 65–70, 1900.)—By Wien's law, the radiant energy of an absolutely black body at an absolute temperature T may be expressed in terms of T and the wave-length λ as follows:—

$$E = T^5 \phi\,[\lambda T] \qquad (1)$$

where ϕ is a function hitherto unknown. The radiation is perfectly known for all wave-lengths if the temperature is given, or for all temperatures when

the wave-length is given. The law further indicates the existence of two natural constants which only depend upon the unit of temperature and the three mechanical units. In conjunction, therefore, with the velocity of light and the gravitational constant we obtain a natural measure for the temperature which is independent of any particular body. The author gives a new and more satisfactory deduction of the above law (1). As regards the distribution of energy in the spectrum, that is governed by the formula

$$\phi_{(x)} = \phi_m \left(\frac{x_m}{x} e^{1-\frac{x_m}{x}} \right)^a \qquad (2)$$

$$5 > a > 2$$

where ϕ_m and x_m are the two natural constants, and ϕ_m is the maximum attained when x is a maximum. Paschen found experimentally $a > 5$. The author finds a value $a = 4{\cdot}5$, and shows that the formula (2) then agrees with the results of Wien, Planck, Rubens, Lummer, and Pringsheim.

E. E. F.

1997. *Magnetic Deflection of Becquerel Rays.* **H. Rubens** and **E. Aschkinass.** (Deutsch. Phys. Gesell., Verh. 2. 2. pp. 13–15, 1900.)—The magnetic deflection of Becquerel rays has been demonstrated by Giesel [see Abstract No. 61 (1900)], and by St. Meyer and v. Schweidler, but in their experiments it was very difficult to follow clearly the course of the rays. But Elster and Geitel have shown [see Abstract No. 60 (1900)], that Becquerel rays can be detected by their effect on a spark-gap. The authors have adopted the following arrangement: The electrodes used are of unequal curvature, the positive one being a rod with rounded end and the negative one a sphere of about 25 mm. diameter. They are connected to an induction machine and adjusted at such a distance apart as just to allow of a steady stream of sparks. On bringing near a radio-active substance the sparks disappear and are replaced by a glow-discharge. The drawback of the method is that the surface of the electrodes is soon affected, and they have to be frequently polished in order to keep them in good order. The drawback can be avoided by placing in parallel with this spark-gap A another B, in which the electrodes are balls of equal size. The electrodes A are drawn so far apart that sparking ceases; the electrodes B are then brought near enough together to allow of steady sparking. If now active rays fall upon A the sparking at B ceases, whereas similar rays falling upon B produce no noticeable effect. In order to get an approximately parallel bundle of rays, the radium-preparation was placed inside a thick lead tube. Experiments with an electromagnet showed that the rays were deflected in the direction in which negatively-charged particles would move in the magnetic field.

D. E. J.

1998. *Radium-barium Salts.* **F. Giesel.** (Deutsch. Phys. Gesell., Verh. 2. 1. pp. 9–10, 1900.)—Transmission of radio-activity is observed when a small quantity of an ordinary bismuth chloride solution is added to a solution of strongly active barium chloride, and the bismuth precipitated by H_2S. A screen shows that the bismuth chloride has become active. The brown-red colour shown by a heap of barium platino-cyanide crystals is also obtained by crossing two crystals [see Abstract No. 1257 (1900)]; one crystal alone appears yellow. This polarisation is not shown either by common or by [illegible] crystallised active barium platino-cyanide. In connection with the [illegible] of rock-salt and potassium bromide by radium rays, it may be

mentioned that barium bromide kept in a closed vessel takes on a yellowish colour and gives a weak smell of bromine. The chloride also in the same way gives a smell of hydrochloric acid. G. E. A.

1999. *Radium Rays in the Electric Field.* **E. Dorn.** (Phys. Zeitschr. 1. pp. 337–338, May 5, 1900.)—The emission from a small quantity of radio-active barium bromide passes between the plates of a condenser 14 mm. apart, and impinges on a barium platino-cyanide screen 2 cm. above the condenser, producing fluorescence. It is found that the light always deviates towards the positive plate of the condenser like kathode rays. Assuming Becquerel's numbers, the displacement of the image is calculated considering the rays to consist of electrically charged masses moving with great velocity, and the observed displacement is considered to agree fairly well with the calculated value. A large part of the rays is absorbed by the positive plate by reason of the small distance of the plates apart, but a calculation gives 0·24 cm. and 0·33 as the respective displacements at the positive and negative sides. In the darkened room the displacement was difficult to measure, but appeared to be 2 or 3 millimetres. G. E. A.

2000. *Electric Fluorescence of Nitrogen.* **P. Lewis.** (Ann. d. Physik, 2. 3. pp. 459–468, July, 1900.)—When a vacuum tube is filled with nitrogen prepared from ammonium sulphate and nitrite, and deprived of oxygen by means of hot copper, the wall of the tube fluoresces for a few seconds under the influence of the discharge, and then ceases. The fluorescence extends not only over the whole interior of the tube, but also over the tubes through which the nitrogen is brought in and pumped out. It disappears soonest where the current is strongest, but can be made permanent by using a continuous stream of fresh nitrogen. Fluorescence is strongest at feeble currents and low pressures. That it is the glass and not the gas which fluoresces is shown by the fact that if a portion of the glass wall is heated it ceases to shine, and only recommences after it has cooled down. Small additions of oxygen, hydrogen, steam, or carbonic oxide diminish the fluorescence. But the purest nitrogen does not show it either, and the author believes that it is due to the admixture of some impurity to the nitrogen. To judge by the spectrum of the fluorescence, that impurity is either water or oxygen, but in exceedingly minute quantities. Very small impurities of oxygen are capable of producing an after-effect in the shape of a fluorescence lingering after the discharge has ceased. E. E. F.

2001. *Phosphorescence of Phosphorus Pentoxide.* **H. Ebert** and **B. Hoffmann.** (Zeitschr. Phys. Chem. 34. pp. 80–86, July 3, 1900.)—The phosphorescence of phosphorus pentoxide has usually been ascribed to the slow oxidation of lower oxides present as impurities. A green phosphorescence is, however, observed even in a vacuum or in an atmosphere of a neutral gas; also with specimens prepared by burning pure phosphorus in which no arsenic, antimony, copper, &c., could be detected, and which had been freed from lower oxides by subliming over red-hot platinum black in an atmosphere of dry oxygen, and were free from moisture and phosphoric acid. The phosphorescence is caused by blue as well as by ultra-violet rays. Commercial pentoxide gives a more persistent white luminescence due to oxidation of lower oxides, in addition to the green fluorescence. T. M. L.

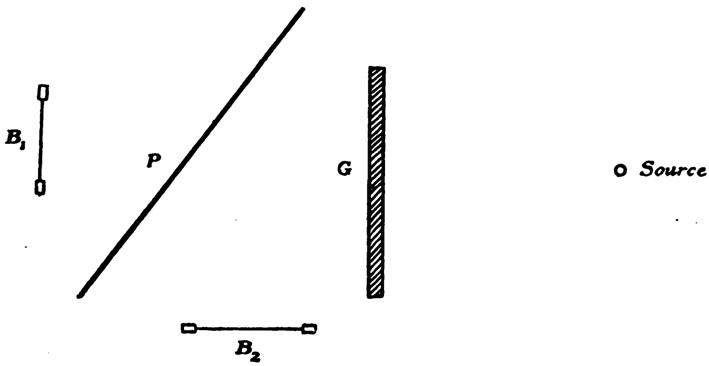
HEAT.

2002. *Thermal Conductivity of Iron.* **E. H. Hall.** (Phys. Rev. 10. pp. 277–310, May–June, 1900.)—This paper is a critical study of the methods and results of the following experimenters: Forbes, Mitchell, R. W. Stewart; Ångström, Neumann, H. Weber; L. Lorenz, Beglinger; and Berget. The author entirely distrusts the results obtained by Forbes's method; he finds a slip in Ångström's final calculation which, when corrected, gives 0·1762 for the value of k at 0° C. in c.g.s. units when the constant value 0·8862 is retained for the specific heat at constant volume, and 0·1655 if allowance is made for the variation of the specific heat with temperature; he considers Lorenz's method particularly well designed for giving the temperature coefficient of variation of k, and Lorenz's number, — 0·0002282, as therefore pretty accurate; he especially eulogises Berget's guard-ring method, and communicates the results of some experiments of his own by this method, which give $k=0{\cdot}1541\ (1-0{\cdot}0003t)$. He generally distrusts the measurements of temperature by the thermoelectric arrangements used, and laments the absence of exact data as to the density of the iron used, and finally discusses the relation of thermal to electrical conductivity. R. E. B.

2003. *Platinum Gas Thermometer,* II. **L. Holborn** and **A. Day.** (Ann. d. Physik, 2. 3. pp. 505–545, July, 1900.)—For work at high temperatures the air thermometer with a platinum-iridium vessel is superior to a porcelain thermometer owing to the absence of softening; the permeation of the gas, which in the case of hydrogen is troublesome, is obviated by substituting nitrogen for air or hydrogen. In continuation of their previous work on the subject, the authors have determined the correction to be applied on account of the expansion of the vessel. This expansion, which demands a correction of 10°, 30°, and 40° respectively at 500°, 1,000°, and 1,150° is not regular, and a further error of 1·5° to 7° is occasioned by the irregularity. The curve of expansion was determined by measuring the expansion of a rod made of the standard alloy, containing 80 per cent. of platinum and 20 per cent. of iridium. With a nitrogen thermometer subjected to the new corrections a number of melting-points of metals were determined, so as to render future tests, especially those of thermo-elements, independent of the nitrogen thermometer. Thus the melting-point of lead was found to be 326·9°, of pure silver 961·5°, and of gold 1,064·0°. The last value was verified by an optical method, the refractive index of air exposed to the temperature of the melting-point being measured. This also gave 1,064°. [See also Abstract No. 1873 (1899).]
E. E. F.

2004. *Liquefaction of Gaseous Mixtures.* **F. Caubet.** (Comptes Rendus, 131. pp. 108–109, July 9, 1900.)—The author presents the results of his investigations on a third group of gaseous mixtures, giving the limiting lines and critical line of a series of mixtures of methyl chloride and sulphur dioxide. These lines afford a verification of previous theory, as they show the existence of the points and lines of Gibbs and Konowalow. Retrograde condensation has not been observed in this group. [See also Abstract No. 843 (1900).]
W. E. T.

2005. *Temperature of a Radiating Body.* **F. Kurlbaum.** (Ann. d. Physik, 2. 3. pp. 546–559, July, 1900.)—The temperature of the surface of a radiating body is usually supposed to be equal to that of the interior; but this is by no means strictly the case, especially when the body is a bad conductor and a good radiator. To determine the actual difference in a concrete case the author made an experiment, the principle of which is indicated in the annexed diagram, where P is a sheet of platinum foil 1μ thick, covered on both sides with platinum black. Light falls through the glass plate G upon the platinum,



and the heated platinum sends heat rays to the bolometers B_1, B_2, placed symmetrically with regard to the sheet. Any difference between the temperatures of the two surfaces will be indicated by a difference in the deflections of the two bolometers. As a result, the author finds a difference of temperature of 0·016° when the sheet is heated 4° above its surroundings, and 0·068° when the sheet is blackened with lampblack instead of platinum black. This difference is, of course, only that which applies to the special case, but anyhow it is smaller than usually supposed. E. E. F.

2006. *Evaluation of van der Waals' Constants.* **P. A. Guye** and **L. Friderich.** (Archives des Sciences, 9. pp. 505–531, June, 1900.)—For 71 substances the constants a and b in van der Waals' form of characteristic are calculated from the experimentally found values of the critical pressure and temperature according to the known formulæ, the particular methods of calculation used being discussed at length. These calculations are made for the characteristic, both with volumes referred to that under unit pressure at 0° C. as unit (in which case it is found that the formula—

$$b = 0·0004496K_c + 0·000001835K_c^2,$$

where $K_c \equiv T_c/P_c$, is very approximately exact), and also with volumes referred to the gramme-molecule. R. E. B.

2007. *Meaning of van der Waals' Constant b.* **L. Boltzmann** and **H. Mache.** (Cambridge Phil. Soc., Trans. 18. pp. 91–93, April, 1900.)—If ν_1 and ν_2 are the numbers of simple and double molecules in a gas per unit volume, molecules of a higher concentration occurring in only negligible amount, formula (238) of Boltzmann's *Vorlesungen über Gastheorie,* without the restriction of χ being constant, gives—

$$\nu_2 = \lambda\nu_1^2, \text{ where } \lambda \equiv 2\pi\int_\sigma^{\sigma+\delta} ds\, s^2 e^{f(s)/mrT},$$

m being the mass of a simple molecule, r the constant for the gas, and T the absolute temperature.

Then $p = (\nu_1 + \nu_2) mrT$, while the total mass of the molecules is $(\nu_1 + 2\nu_2) m \equiv 1/v$, v being the specific volume; these give—

$$\nu_1 + 2\nu_2 = 1/mv \equiv x, \quad \nu_1 + \nu_2 = p/mrT \equiv y,$$

and thus—

$$x - y = \lambda \left\{ x - 2(x - y) \right\}^2 \simeq \lambda x^2,$$

if $x - y$ is small compared with $\frac{1}{2}x$, *i.e.*, if ν_2 is small compared with $\frac{1}{2}\nu_1$; and consequently—

$$p = (x - \lambda x^2) mrT = rT/v - \lambda rT/mv^2.$$

The authors then simply *assert* that v must be diminished by the volume of the envelopes of the molecules, viz., $\frac{4}{3}\pi\sigma^3/m$, and without further reason put this as van der Waals' constant b. Their value for a is $\lambda rT/m$ as above; this they develop on the assumption that $f(s)$ is constant, obtaining—

$$\alpha rT \Sigma_{n=1}^{n=\infty} (\beta/T)^{n-1} \left\{ (n+1)(n+2) + 2(n+2)/\epsilon + 2/\epsilon^2 \right\} / (n+2)!$$

where α, β, ϵ are magnitudes that can be simply described in terms of the theory. [The notation has been altered for simplicity and clearness.]

R. E. B.

2008. *Construction of a ϕt-diagram from an Indicator Card.* **H. T. Eddy.** (Amer. Assoc., Proc. 48. pp. 93–94, 1899.)—The characteristic $pv = ct$ is assumed, and the vp-diagram is changed into a ϕt-diagram by the intermediate use of a vt-diagram. R. E. B.

2009. *Characteristic of Steam.* **O. Tumlirz.** (Akad. Wiss. Wien, Sitzb. 108. pp. 1058–1069, 1899.)—Battelli's results from $-6{\cdot}16°$ C. to $281{\cdot}41°$ C. are represented by the equation—

$$p(v + 0{\cdot}008402) = 3{\cdot}4348T$$

as exactly as by that of Clausius' type which Battelli gives, except in the immediate neighbourhood of the points of condensation. Within these limits, then, superheated steam is a perfect gas in so far that its intrinsic energy is a function of the temperature only, since $(\partial E/\partial v)_T = (\partial p/\partial T)_v - p = O$. Pushed to the points of saturation this formula gives volumes that are too great or too small according as the temperature is below or above $49{\cdot}46°$ C. R. E. B.

2010. *The two Specific Heats of Steam.* **O. Tumlirz.** (Akad. Wiss. Wien, Sitzb. 108. pp. 1395–1405, 1899.)—The characteristic found for superheated steam (see preceding Abstract), of the form $p(v + a) = RT$, requires the two specific heats to depend, if they vary at all, on the temperature only, and their difference in dynamical measure to be equal to R: adiabatic expansion from p,T to p',T' with this characteristic also gives $\int_T^{T'} (K/T)dT = R \log (p'/p)$ where K is the isopiestic specific heat. But Grashof showed that Hirn and Cazin's experiments give $\log (p'/p) = n \log (T'/T)$, where n is a constant; hence therefore $K = Rn$, or both specific heats are constant. The author finds $4{\cdot}3045$ as the best value of n, and thus, in heat units—

$$C = (3{\cdot}4348 \times 13{\cdot}596 \div 424) \times 4{\cdot}3045 = 0{\cdot}4761, \; c = 0{\cdot}3639, \; C/c = 1{\cdot}3026.$$

The work done by the internal forces in the particular case when steam becomes saturated at $137{\cdot}34°$ C. is then found to be equivalent to $3{\cdot}461$ calories, on the assumption [see Abstract No. 624 (1898)] that in the neighbourhood of saturation $C = 0{\cdot}5236$, Planck's value $0{\cdot}47$ being rejected for reasons given.

R. E. B.

2011. *The Calculus of Probabilities as Applied to Dynamical Systems.* **E. Zermelo.** (Phys. Zeitschr. 1. pp. 317–320, April 14, 1900. Göttinger Habilitationsvorlesung, March 4, 1899.)—The author objects to the assumptions that have hitherto been made in the kinetic theory of gases for the determination of probabilities and average values on the ground that they are taken to be applicable at *all* stages of the motion, whereas, the changes in the motion being due to fixed mechanical laws, the possible applicability of these assumptions at one stage does not necessarily entail their applicability at a subsequent stage. Now the probability of any state of motion is necessarily equal to that of the initial state from which it originated, so that the probability is independent of the time; we may thus define the probability that a particular state of motion at time t lies within a given range of possible states g, which are included within the whole range G that comes into consideration, as the ratio γ/Γ of the "extents" of these ranges, which are defined as the $2n$-ple integral $\int \Pi dp\, \Pi dq$ taken over the respective ranges, where q denotes the type position-variable, p the corresponding momentum, and Π the continued product of similar magnitudes; since, by Liouville's theorem, these extents do not alter with the time. It then follows that (1) the average value of dS/dt in every invariable range G, where S is any single-valued differentiable function of the state of motion, is zero; (2) if σ is an approximation to a value S_0 of the single-valued function S, the average value of dS/dt within the range given by $S_0 - \sigma < S < S_0 + \sigma$ is zero. The author proposes to re-investigate Maxwell's law from the above definition of probability without any further hypothesis. R. E. B.

2012. *Reduction of Problems of Heating by Radiation to that of Heating by Contact. Heating of a Wall of Infinite Thickness.* **J. Boussinesq.** (Comptes Rendus, 130. pp. 1732–1736, June 25; 131, pp. 9–13, July 2; and pp. 81–86, July 9, 1900.)—In his former paper [see Abstract No. 1820 (1900)] the author gave as an example of his theory the case of a wall of infinite thickness bounded by the plane $x = o$, originally given at temperature zero, and heated by an external source producing on that face the temperature $u = f(t)$, where $f(t)$ is an arbitrary function of the time. In the present paper he gives a second example, namely, that of a wall of infinite thickness bounded by the plane $x = o$, and originally at temperatures denoted throughout its thickness by an arbitrary function of x, tending towards a constant as x becomes infinite. The mathematical difficulties of the subject are due, says the author, to the employment by Fourier, on whose formulæ the investigation is based, of sines and cosines of real arcs, and consequently of undulations, which can have no place in a uniform state. It becomes necessary to eliminate these unnecessary undulations.

In pp. 9–13 the author proposes to give two examples of permanent heating. In the first example the wall is bounded by the infinite surface $x = o$, but the external temperature u, on that face is a function of y and z. This is intended to lead up to the case of the temperature of the earth's crust, under the (supposed constant) action of the sun, assuming that owing to diversities of the atmospheric conditions local inequalities of temperature exist. It is shown that the local inequalities of temperature diminish as we proceed inwards from the surface, and become insensible at a depth considerable in relation to the spaces on the surface over which the local inequalities exist.

In pp. 81–86 the author treats of a homogeneous sphere, radiating into space, the temperature of which, while invariable with the time, has given

values u_e at different points of the surface. The origin being taken at centre of the sphere, and R being the radius, the problem solved is to form a function u which shall have the value zero at the centre, and vary continuously to u_e at each point on the surface. S. H. B.

2013. *Cooling of the Earth's Crust.* **J. Boussinesq.** (Comptes Rendus, 130. pp. 1652–1658, June 18, 1900.)—The writer refers to his former paper [see Abstract No. 1820 (1900)] in which he found the formula $\int_{\omega}^{\infty} \varepsilon^{-\omega^2} d\omega$ to express the temperature of a body of infinite extent, bounded by a plane surface, raised to a uniform temperature u_o and then left to cool by radiation from that plane surface into space supposed at zero. The temperature on the surface is given by—

$$u = \frac{2u_o}{\sqrt{\pi}} \varepsilon^{a^2h^2t} \int_{ah\sqrt{t}}^{\infty} \varepsilon^{-\omega^2} d\omega$$

and this becomes approximately, for large values of t, $\frac{u}{ah\sqrt{\pi t}}$.

These two formulæ are precisely those obtained by Fourier to express the successive temperatures on the earth's surface (not taking into consideration the sun's action) from which formulæ Fourier deduces his theory of the cooling of the earth. The author discusses this theory. The effects due to solar action will be periodic, in daily or yearly periods, and will at considerable depths become insensible. The temperature of surrounding space will be the same, he says, at the poles as at the equator, and will continue unchanged throughout long periods of time. Treating this temperature of space as zero, the equations representing the earth's temperature are—

$$\frac{du}{dx} - hu = o \text{ (for } x = o)$$

and—

$$\frac{du}{dt} = a^2 \frac{d^2u}{dx^2}.$$

The author, making an actual calculation on certain hypotheses, obtains 45,000 centuries as the time which may have elapsed since the earth's surface had a temperature of 1,000° C. S. H. B.

SOUND.

2014. *Photography of Sound Waves.* **R. W. Wood.** (Roy. Soc., Proc. 66. pp. 288–290, May 12, 1900. See also Nature, 62. pp. 342–349, Aug. 9, 1900, for an extended account.)—The sound-waves are produced by means of an electric spark, and illuminated and photographed by the light of a second spark properly timed with reference to the first. The author remarks that in a former paper [see Abstract No. 89 (1900)] he treated of photographs of sound-waves undergoing reflection, refraction, and diffraction; but by means of an improved apparatus he has obtained a more complete series of photographs.

Conjugate foci for elliptical mirrors aplanatic for rays issuing from a point, the transformation of a spherical into a plane wave by a parabolic mirror, and the effect of spherical aberration in circular mirrors are well shown. The transformation of a spherical wave into a plane wave by a cylindrical carbonic acid lens of exceedingly thin collodion, the circular flat ends being made of mica, can also be demonstrated, and the reflection of a single wave from a flight of steps forming a train of waves, in other words, a musical note.

In dealing with the reflection of a plane wave from a hemispherical mirror, being unable to control the time interval between the sparks with sufficient accuracy to take a series of photographs of an actual wave suitable for kinematographic reproduction, the author adopts the expedient of preparing a large number of geometrical constructions (100 or so) for the wave at successive intervals of time and photographing them upon a kinematographic film. The wave fronts are constructed as follows: Around points upon the surface of the mirror circles are described tangential to the plane wave; these circles will be enveloped by another surface behind the mirror (the orthogonal surface), which is an epicycloid formed by the rolling of a circle of diameter equal to the radius of the mirror upon the back surface of the same. Normals to this orthogonal surface can be constructed by drawing the locus of the centre of the generating surface, describing about various points of it circles whose radii shall be equal to the radius of the mirror, and joining the points where each circle cuts the epicycloid and the mirror respectively. These normals will represent the reflected rays, and if equal distances be measured off upon them from the orthogonal surface, the points so found will lie upon the reflected wave fronts. After a time a second reflection will occur, and to determine the wave front for it measurements have to be made round a corner. Photographs are given of the waves and a figure to show the construction for the wave-front. W. C. O.

ELECTRICITY.

THEORY AND ELECTROSTATICS.

2015. *Robin's Method of Defining Electrostatic Potential.* **E. Neumann.** (Gesell. Wiss. Göttingen, Nachr., Math-Phys. Klasse, 3. pp. 291–301, 1899.)—We are to suppose a closed surface σ of any form subject (according to Robin) to the condition of being everywhere convex: p is any point either in the enclosed or in external space, and r_p is the distance from p of any point on the surface σ, or in free space. If there be on σ a distribution of density g_σ, $V_p = \frac{1}{2\pi}\int g_\sigma \frac{d\sigma}{r_p}$, then V_p is the potential of that distribution, and $\left(\frac{dV}{d\nu}\right)_i$ and $\left(\frac{dV}{d\nu}\right)_a$ are the usual derivatives of V in the normal torwards the internal or external space respectively. Then form a new distribution on σ, of density equal to the arithmetic mean of $\left(\frac{dV}{d\nu}\right)_i$ and $\left(\frac{dV}{d\nu}\right)_a$, and call that g'_σ. Then V'_p is the potential of the new distribution g'_σ. And so we form the series of successive potentials V_p, V', V^n_p. Robin's theorem asserts that the series $V_p + V'_p + \cdot$ &c., is convergent.

Neumann then considers a class of integrals, to which attention was called by Schwarz. If $V^{(\kappa)}$ and $V^{(\lambda)}$, Schwarz's integrals, be two members of the series of V'_s—and if we form the integral

$$\int\left(\frac{dV^{(\kappa)}}{dx}\frac{dV^{(\lambda)}}{dx} + \text{\&c.}\right)d\tau$$

throughout either the internal or external space it is found that the result depends only on the sum $\kappa + \lambda$, and so may be written $L^{(\kappa+\lambda)}$. It follows that if $\kappa + \lambda$ be even, L^{2n} is positive, and approaches a limit as n increases.

The author generalises this theorem, forming two series of V'_n, and taking in each case $V^{(\kappa)}$ from one and $V^{(\lambda)}$ from the other series. It is found that in this case also the result depends only on $\kappa + \lambda$. Using now special forms of g for the two series, the author obtains a simplification of Poincaré's generalisation of C. Neumann's method of the arithmetic mean, and shows that the convexity of the surface σ is not an essential condition, provided that at each point each principal radius of curvature is finite and continuous. Finally the author discusses the consequence of Robin's series. S. H. B.

2016. *Thermodynamics of Cells.* **C. Liebenow.** (Ann. d. Physik, 2. 3. pp. 636–648, July, 1900.)—Riecke and others have postulated the generation of an electric current by every heat current, and *vice versâ.* [See Abstracts Nos. 1516 (1899), and 138 (1900).] The author attempts to account for this by assuming that the heat consists in the vibrations of the negative particles, now usually called electrons. Anything which moves these negative electrons will *move* the heat attached to them by convection, and so every electric current

will go hand in hand with a heat current. The heat can be calculated from the equation—

$$\Phi = -0{\cdot}24\,\mathrm{T}i\frac{d\mathrm{E}}{d\mathrm{T}},$$

which gives the amount of heat conveyed by a current i through any cross-section of the metal in one second. For copper, the amount of heat thus supplied to each gramme-atom precipitated from solution would be 870 calories at 0°. But since the total heat of the gramme-atom is about twice that amount, it may be said that half the total heat of the metal is conveyed by the negative electron, and the other half by the positive electron. The author further shows that all metals in the solid state are monovalent, and that the atomic heat of negative and positive electrons is $870/273 = 3{\cdot}2$, or about the same as the atomic heat of monatomic gases at constant volume.

E. E. F.

2017. *Thermo-magnetic Action.* **W. Voigt.** (Gesell. Wiss. Göttingen, Nachr., Math-Phys. Klasse, 3. pp. 302–305, 1899.)—The author refers to two former works of his own (Gött. Nachr., 1895, p. 135, 1898, p. 113.) Experiments show, he says, that in thermo-magnetic processes two kinds of action are in evidence—one reversible, the other irreversible. These are distinguished by separate linear equations of the form—

$$\left.\begin{aligned} \mathrm{X} &= -\theta\,\mathrm{R}\frac{d\tau}{dy}, \\ \mathrm{Y} &= +\theta\,\mathrm{R}\frac{d\tau}{dx}, \\ \mathrm{Z} &= 0, \end{aligned}\right\}\text{ for the reversible actions}$$

where the magnetic field is in direction Z—X, Y, Z are components of E.M.F., and θ is a constant dependent on the nature of the substance. Analogous equations hold for the flow of heat consequent on the electric current whose components are u, v, w. For the irreversible actions he gives the equations $\mathrm{X}' = -\nu\,\theta'\mathrm{R}\frac{d\tau}{dy}$, $\mathrm{Y} = \nu\,\theta'\mathrm{R}\frac{d\tau}{dx}$, where ν is a parameter parallel to Hall's rotation coefficient, and $\theta' = \frac{d\theta}{d\mathrm{T}}$.

If $\Phi = \theta - \mathrm{T}\theta'$, then $\sigma = \frac{d\Phi}{d\mathrm{T}}$ is Thomson's "specific heat of electricity." These formulæ are compared with the results of experiments by Ettinghausen, Nernst, and Everdingen. The author also refers at some length to a work by Moreau, who, without being aware of the author's work, obtained results which in the main agree with his: one point of difference is discussed.

S. H. B.

2018. *Atmospheric Electricity.* **J. Elster** and **H. Geitel.** (Phys. Zeitschr. 1. pp. 245–249, March 3, 1900. Paper read before the Brunswick Scientific Society by H. Geitel, Nov. 16, 1899.)—Normal atmospheric airs contains nearly equal numbers of positive and negative ions. A positively charged conductor attracts the negative ions, and a negatively charged conductor the positive ions, and the conductor is gradually discharged by them. Fog destroys the mobility of the ions by attaching them to water drops. In the earth's electrostatic field the free ions undergo a partial separation. Positive ions gather about the mountain-tops, and produce a discharge of negative

electricity from them. An unimpeded acquisition of negative electricity takes place on the earth's surface wherever the negative ions penetrate below the surface, as they practically do when they descend below the foliage in a forest. This may account for the earth's permanent negative charge. Since a cloud stops the mobility of ions, and interferes with their steady diffusion, it may produce the accumulation of large quantities of electricity, which are only neutralised by disruptive discharges. The daily periodic variation of atmospheric electricity may be explained by the varying amount of moisture condensed in the air. For a full ionic theory of atmospheric electricity a considerable amount of material remains to be accumulated. E. E. F.

2019. *Inductance and Electrostatic Oscillations.* **P. de Heen.** (Comptes Rendus, 130. pp. 1071–1072, April 17, 1900.)—On the ordinary phenomena of electrostatic *influence* there appears to be superposed in certain cases a phenomenon of inductance comparable to that of electro-dynamics.

If a charged conductor is caused to approach another conductor, or if the first conductor is charged or increased in potential, the second conductor becomes charged with electricity of the same kind. The result is reversed when the inverse operations are performed. A conductor set in motion in the neighbourhood of a second conductor tends to displace itself in the inverse sense of the motion communicated to it.

Consider a gold-leaf electroscope *of which the conductor is joined to earth* and place under these conditions, at a *distance determined* and relatively small, the *positive* conductor of a Leyden jar. The electroscope being set in action the phenomenon of influence manifests itself and the gold-leaves separate with a quantity relatively feeble. Influence is manifested only.

If, in the second place, the electroscope being discharged and the Leyden jar being at a great distance, this latter is caused to approach up to the distance which corresponds to the first experiment, the phenomenon of *inductance* is produced, the gold-leaves diverge with a quantity *incomparably greater* than in the first experiment, and the electroscope is charged *positively.*

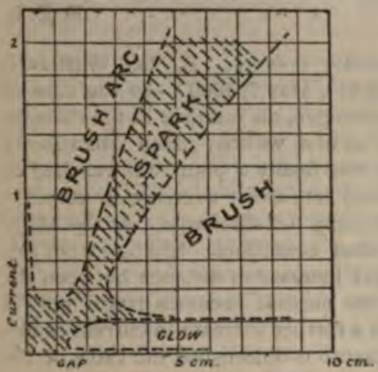
In the third place, perform the first experiment, then withdraw the jar slowly. At a certain moment *influence* will cease to be sensible and the gold-leaves will come together. If, however, the movement of the jar is continued the electroscope becomes *negatively* electrified by *inductance*, and the gold-leaves separate anew.

It results from this that if we determine an oscillation of potential, this oscillation will transmit itself to a distance, very probably by *inductance* and not by *influence*, and if *one* of the poles of a strong coil worked by a Wehnelt interrupter is put in communication with a stretched copper wire, or with a square of large wire gauze, the electromagnetic oscillations developed are capable of illuminating a vacuum tube enclosed in a thick pasteboard box. A very sensitive radio-conductor permits of recognising the absence of the electromagnetic oscillation. J. J. S.

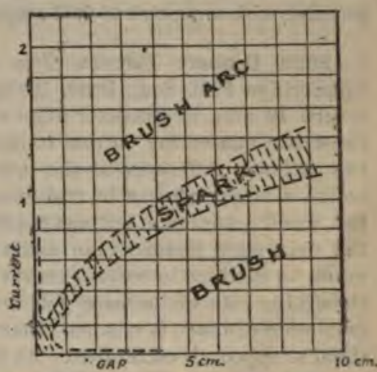
DISCHARGE AND OSCILLATIONS.

2020. *Continuous Discharges in Air.* **M. Toepler.** (Ann. d. Physik, 2. 3. pp. 560–623, July, 1900.)—When a battery of cells is used as a source of electric energy, the constant element in the circuit is the E.M.F., while the current depends upon a variety of external conditions. The case is reversed on using an influence machine driven at a constant speed, for then the mean *current strength* is the constant element, and the E.M.F. is the dependent

variable. The author investigates the conditions of the generation of a continuous discharge in air at atmospheric pressure as dependent upon the current strength. This continuous discharge may appear in four different forms, viz., glow, brush, brush-arc, and flame-arc. All of these may be either positive or negative, and the relative importance of the positive and negative phenomena depends upon the capacity and shape of the electrodes. To simplify matters, the author supposes that one side of the discharge is highly developed at the expense of the other, so that either the positive or negative discharge takes up practically the whole field. This may be brought about, for instance, by opposing a good pointed conductor to a bad and flat conductor, such as a slate.



POSITIVE DISCHARGE.



NEGATIVE DISCHARGE.

As a general rule, an increase in the current strength brings about a transition from the glow to the brush and from the brush to the brush-arc discharge. But this transition is only continuous when the capacity in the circuit is very small. At greater capacities, the three regions of continuous discharge are separated by two regions of discontinuous (spark or line) discharge. In the diagrams, the regions of discontinuous discharge are shaded. The diagrams represent the conditions obtaining with 10 cm. of capacity in the circuit, the current bring expressed in milliamperes. With higher capacities, the shaded region encroaches very considerably upon the brush-arc region, especially in the positive discharge. E. E. F.

2021. *Globe Lightning.* **M. Toepler.** (Ann. d. Physik, 2. 3. pp. 623–635, July, 1900.)—This is an appendix to the paper referred to in the preceding Abstract. The author points out that two more or less continuous forms of electric discharge occur in nature. One is the glow discharge known as St. Elmo's fire, the other is that known as globe or ball lightning. The nearest experimental analogue of ball lightning is the brush arc, including the special forms of it described by Righi and others, more especially those observed under slightly reduced pressure. The author regards globular lightning as a short continuous lightning discharge along the path previously cleared by "fork" lightning. The globe marks a portion of the lightning track where there is a particularly high potential gradient. The shape, as gathered from the descriptions, is always somewhat elongated. The motion of the mass is accounted for partly by electrostatic forces similar to those which displace a shower of sparks, and partly by the motion of the air, which displaces and deforms the track. The "foot" of the track may be displaced for a con-

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Ionic Conductivity of the Atmosphere. **J. Elster** and **H. Geitel.** (Ann. , 2. 3. pp. 425–446, July, 1900.)—Observations made with an electro- otected against wind and rain but exposed to ordinary air show that oation of an electric charge is due to the presence of ions in the re. The presence of fog, smoke, or dust reduces the rate of dis- nstead of increasing it. The discharge is also reduced by enclosing oscope in a limited air space, probably owing to the limited number riginally contained in the latter. The dissipation of positive and charges takes place at approximately the same rate, except at high such as the Brocken and the summit of the Säntis, where the rate tion may be from two to ten times as great for negative as for harges. The authors connect this observation with the fact that light ionises the air, and that therefore the highest strata of the are probably ionised by the sun's rays. The ions thus pro- diffused through the atmosphere at rates depending upon their Such ions would account for the conductivity of the atmosphere vations, and explain to some extent the luminous and magnetic of the aurora. E. E. F.

ternal Electric Field of a Discharge-Tube. **F. Schicht.** (Akad. Sitzb. 108. pp. 814–824, 1899.)—The fall of potential inside a e has been carefully examined, but apparently the electrostatic -space surrounding the tube has not hitherto been investigated. experiments were made with three tubes of lengths 17·5, 36·5, espectively: the anodes were points and the kathodes were 2·5 cm. in diameter. He deduces the following conclusions: ials decrease when the distance from the tube increases, and the immediate neighbourhood of the tube. It is, however, the maximum value is not near the anode, but about half-way (2) As the pressure diminishes the potentials also diminish nimum (when striation begins) and then increase. (3) The gher when a spark-gap is introduced than when it is absent. charge takes place in a magnetic field (lines of force per- n of discharge) the potentials are higher than under ordinary D. E. J.

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$$L \frac{dI}{dt} + RI = -E$$

$$I = C \frac{dE}{dt}$$

expression is found for the maximum E.M.F. bet- rms of the expression are considered in so far

siderable distance, thus giving the impression of a free wandering of the globe, and the steady discharge may be kept up for some 30 seconds under favourable circumstances. As a rule, another spark discharge (ordinary lightning) ends the display, and the detonation is usually attributed to the ball itself. As regards the current intensity in globe lightning, that may possibly at some moments amount to 10,000 amperes. But the more usual current intensity does not exceed some 5 amperes, as may be judged from the size of the globe (that of a hen's egg or a child's head) and from its duration as compared with the brush-arc and forked-lightning flash. But globe lightning is possible even at much lower currents. To judge from laboratory analogies, the formation of a faintly luminous mass the size of a head would already be possible with a current of 0·01 ampere. E. E. F.

2022. *Distance Between Striæ in Positive Column.* **R. S. Willows.** (Cambridge Phil. Soc., Proc. 10. pp. 302–316, May 7, 1900.)—In the case of a tube 12 mm. in diameter filled with hydrogen, an increase in the rheostat resistance caused the current to decrease at first, without much alteration of the potential difference at the terminals, but finally a point was reached at which a large increase in resistance caused no further decrease in current; this was the minimum current required to carry the discharge. At this stage the striæ were steadier than under any other conditions. Starting from this point, an increase in current causes a rapid increase in distance between the striæ; the rate of increase gets less as the current becomes larger until a maximum distance is reached, after which a further increase in current causes them to approach each other. As the pressure is diminished the value of the maximum distance increases, but the strength of current required to produce it becomes less, so that at pressures of a few tenths of a mm. that phase in which an increase of current produces a separation of the striæ may be nearly absent, and the current required to produce the maximum separation is nearly equal to the smallest current required to maintain the discharge. The presence of this maximum explains the observation of Müller and de la Rue, that sometimes an increase in current causes the striæ to separate, while in other cases the reverse effect is obtained. With air and nitrogen the effect is rather different. Starting from a current just large enough to maintain the discharge, an increase causes a rapid separation of striæ nearly proportional to the current until the latter is nearly four times its original amount, after which the distance between is constant.

With respect to the effect of pressure, Goldstein from his measurements deduced the following law: If d is the distance between two striations and ρ the density of the gas, then, for a given gas, d varies as ρ^{-n} where n is somewhat less than unity. The author finds that the sides of the tube exercise a controlling action and that Goldstein's law may be more accurately replaced by the following: If the striæ do not reach to the edge of the tube, then, for the same current, their distance apart varies inversely as the pressure.

At pressures between 1 mm. and 0·5 mm. the striæ are further apart in hydrogen than in nitrogen and air: for the last two gases the separation is the same. The rate at which the distance between successive striæ decreases as the pressure increases is much greater in the dense gases, and is greater in wide tubes than in narrow ones.

The striæ are further apart the wider the tube, but the distance between bears no simple relation to the diameter or section of the latter. Goldstein's second law, "That if d is the distance between the striæ, then the ratio of the two values of d at two given pressures is the same for all tubes," is very

approximately true when the discharge reaches to the sides of the tube, but does not hold when the distance between the striæ varies inversely as the pressure; in this case the ratio is greater for wide tubes than for narrow ones. D. E. J.

2023. *Ionic Conductivity of the Atmosphere.* **J. Elster** and **H. Geitel.** (Ann. d. Physik, 2. 3. pp. 425–446, July, 1900.)—Observations made with an electroscope protected against wind and rain but exposed to ordinary air show that the dissipation of an electric charge is due to the presence of ions in the atmosphere. The presence of fog, smoke, or dust reduces the rate of discharge instead of increasing it. The discharge is also reduced by enclosing the electroscope in a limited air space, probably owing to the limited number of ions originally contained in the latter. The dissipation of positive and negative charges takes place at approximately the same rate, except at high altitudes, such as the Brocken and the summit of the Säntis, where the rate of dissipation may be from two to ten times as great for negative as for positive charges. The authors connect this observation with the fact that ultra-violet light ionises the air, and that therefore the highest strata of the atmosphere are probably ionised by the sun's rays. The ions thus produced are diffused through the atmosphere at rates depending upon their velocities. Such ions would account for the conductivity of the atmosphere at high elevations, and explain to some extent the luminous and magnetic phenomena of the aurora. E. E. F.

2024. *External Electric Field of a Discharge-Tube.* **F. Schicht.** (Akad. Wiss. Wien, Sitzb. 108. pp. 814–824, 1899.)—The fall of potential inside a discharge-tube has been carefully examined, but apparently the electrostatic field in the air-space surrounding the tube has not hitherto been investigated. The author's experiments were made with three tubes of lengths 17·5, 36·5, and 71 cm. respectively: the anodes were points and the kathodes were circular discs 2·5 cm. in diameter. He deduces the following conclusions: (1) The potentials decrease when the distance from the tube increases, and are greatest in the immediate neighbourhood of the tube. It is, however, remarkable that the maximum value is not near the anode, but about half-way along the tube. (2) As the pressure diminishes the potentials also diminish at first to a minimum (when striation begins) and then increase. (3) The potentials are higher when a spark-gap is introduced than when it is absent. (4) When the discharge takes place in a magnetic field (lines of force perpendicular to path of discharge) the potentials are higher than under ordinary circumstances. D. E. J.

2025. *Spark Due to Break.* **K. R. Johnson.** (Electrician, 45. pp. 281–282, June 15, 1900.)—For a circuit composed of coil, battery, and make and break, the terminals of which are connected to the coatings of a condenser, the equations for the extra current,

$$L \frac{dI}{dt} + RI = -E$$

and—

$$I = C \frac{dE}{dt}$$

are integrated and an expression is found for the maximum E.M.F. between the terminals. The terms of the expression are considered in so far as they

influence the suppression of the spark, and, a similar expression being deduced from a formula of Heaviside's for the potential at a point on a cable, it is argued that there is little difference, in considering the spark or its suppression, whether the condenser is situated at the ends of the broken circuit or the capacity of the circuit is uniformly distributed. And as every practical case is intermediate between these extremes the reasoning may be true for a circuit in general. G. E. A.

2026. *Disruptive Discharge Phenomena.* **W. J. Humphreys.** (Phys. Rev. 10. pp. 311–316, May–June, 1900.)—When the poles of an influence machine are separated beyond the ordinary limits of sparking, a spark can be caused to pass, sometimes through nearly double that distance, by drawing a small spark, by the knuckle, or otherwise, from the negative pole. The spark between the poles is then either a disruptive or a brush discharge. It is important that the outer coatings of the Leyden jars of the machine should be connected by a conductor. Nothing of the kind occurs when those coatings are insulated from each other, nor when the auxiliary spark is taken from the positive instead of from the negative pole of the machine. The author admits that the effect is the result of surging, but he points out that it is not clear why the oscillations should not be equally great for positive and negative impulses. R. A.

2027. *Theory of Electric Waves in Wires.* **G. Mie.** (Ann. d. Physik, 2. 2. pp. 201–249, June, 1900.)—Instead of the case of a single wire surrounded by a hollow cylinder serving as a return circuit, the author deals with two infinite parallel wires in which the displacement currents in the insulating medium parallel to the conductor are negligible. This gives a theoretical approximation to Lecher's wire system.

For very slow oscillations, the velocity of propagation and the damping may be calculated in a simple manner from R, the resistance of the conductor; L, its inductance; C, its capacity, and A, the reciprocal of the insulation resistance, all per unit of length. For if I is the current intensity and P the line integral of the electric force between the two conductors, t the time, and z the distance along the wire from an arbitrary origin, the following two equations hold good—

$$\left.\begin{aligned} -\frac{dI}{dz} &= C\frac{dP}{dt} + AP \\ -\frac{dP}{dz} &= L\frac{dI}{dt} + RI \end{aligned}\right\} \qquad (1)$$

All the quantities are supposed to be measured in electromagnetic units. The equations imply that the electric circuit is a closed curve and that the line integral of the electric force round a closed curve equals the change in time of the magnetic flux through the curve. They are Maxwell's equations in a simplified and special form.

Putting—

$$I = C_1 . e^{2\pi int - \left(\frac{2\pi}{l} - \kappa i\right) iz},$$

$$P = C_2 . e^{2\pi int - \left(\frac{2\pi}{l} - \kappa i\right) iz},$$

where n is the frequency, l the wave-length, and κ the damping factor, equations (1) give—

$$\left(\frac{2\pi}{l} - \kappa i\right)^2 = -(R + 2\pi inL)(A + 2\pi inC) \qquad (2)$$

Denoting the radius of the wires by a, the distance between their axes

by $2a$, the conductivity of the wire by λ_i, that of the insulator by λ_a, and its dielectric constant by ϵ, and putting the permeability, μ, of the wire equal to that of the insulator, we get—

$$\left.\begin{aligned} R &= \frac{2}{\pi a^2 \lambda_i} \\ L &= 4\mu ln\frac{2a}{a} + \mu \\ A &= \frac{\pi\lambda_a}{ln\frac{a+\sqrt{a^2-a^2}}{a}} \\ C &= \frac{1}{9\times10^{20}}\,\frac{\epsilon}{4ln\frac{a+\sqrt{a^2-a^2}}{a}} \end{aligned}\right\} \quad (3)$$

These values only apply when the oscillations are so slow and the wire so thin that the section of the wire may be supposed to be traversed by the current in a uniform manner.

The author proceeds to show that as long as the displacement current in the insulator parallel to the wires is negligible, equation (2) remains in force, and also the values for A and C in equations (3), but that when the oscillations become rapid, additional terms, dependent upon n, must be added to R and L, chiefly owing to the reduction of the effective sectional area; then, however, n becomes large also owing to a difference in the arrangement of the magnetic lines of force outside the conductor. But if the displacement current also takes a part in the return circuit, not only L, but also A and C are thereby affected, and in equation (2), which still remains in force, the imaginary quantity i must be replaced by a more complex term.

The author's results are calculated for an infinite pair of wires, but a finite ending simply introduces a radiation into space and a partial reflection which obeys the same laws as those of the primary oscillation. E. E. F.

2028. *Increase of Resistance of Radio-conductors.* **É. Branly.** (Comptes Rendus, 130. pp. 1068–1071, April 17, 1900.)—An account of the repetition of previous experiments (1891) on the increase of the resistance of certain radio-conductors under electric influences which generally produce diminution of resistance. The author has been confirmed in his opinion that the increase of resistance depends, like the diminution, on a physical condition of the insulating layers interposed. In one of the experiments a tube containing filings of pure gold was placed between two rods of pure gold, and its resistance before any electric action was found to be 400 ohms. A current was sent for thirty seconds from a battery through the radio-conductor and a column of liquid of 3,000,000 ohms resistance. With a battery of 8 volts the resistance became 160 ohms, and decreased with increasing battery power to 25 ohms when the E.M.F. was 160 volts. When, then, the spark from a small Wimshurst machine was caused to act at a distance and brought gradually nearer, the resistance finally fell to 6·5 ohms. On touching the tube containing the filings with one of the poles of the machine the resistance *increases;* it became gradually greater than 10,000 ohms. Under similar treatment a tube containing peroxide of lead exhibits increasing resistance as the battery power is increased; and the resistance increases when the spark from an electrical machine is brought gradually nearer. J. J. S.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

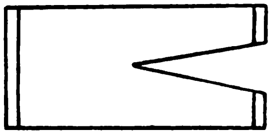
2029. *Dielectric Strength of Oils.* **T. Gray.** (Amer. Assoc., Proc. 48. pp. 122–123, 1899.)—The paper gives the results of experiments to determine the dielectric strengths of oils in layers of varying thickness. The variations of dielectric strength under continued electric stress made the results very irregular, and drying the oils by calcium chloride did not remove the trouble, but reduced the dielectric strength. The average of a large number of results shows that the dielectric strength per cm. thickness decreased slightly with the thickness of the layer. For thicknesses of from 1 to 8 cm. the dielectric strength of vaseline decreased from 131 to 91 kilovolts per cm.; paraffin, sp. gr. 0·28, from 91 to 70; ditto, sp. gr. 0·29, from 101 to 64; natural West Virginia crude oil, sp. gr. 0·29, from 81 to 62. G. H. B.

2030. *Hysteresis in Liquid Dielectrics.* **A. Artom.** (Elettricità, Milan, 19. pp. 374–375, June 16, 1900.)—The author has repeated for liquid dielectrics Arnò's experiments on hysteresis in solid dielectrics, observing the rotation of a film of the liquid in a rotating electrostatic field. The film of liquid was produced by covering a small cylinder of tin-foil (2 cm. × 1 cm. in diameter) with fine copper gauze, and immersing the cylinder in and filling it with the liquid. The cylinder was suspended by a silk fibre in an electrostatic field of from 10,000 to 12,000 volts with a frequency of 42, and was found to rotate with varying velocities according to the liquid employed. G. H. B.

2031. *Electrical Resistance of Gases.* **W. Kaufmann.** (Phys. Zeitschr. 1. pp. 348–349, May 12, 1900.)—The only directly measureable or comparable magnitudes are the current (C) and the electromotive force (E), and the resistance (R) is the quotient E/C or dE/dC. The two quotients are identical and the resistance is constant only when the current is proportional to the E.M.F. Three methods have been used for measuring the resistance of gases. I. A current of any value C is sent through the gas. The gas is then replaced by a metallic resistance R, which allows the same current to pass. Or the electromotive force E, which produces this current, is measured and then $R = E/C$. In general it is found that R is not independent of C. II. Arons and others have placed the gas and the source of current in a Wheatstone's bridge, using an alternating current and a telephone, and replacing the gas by a metallic resistance R. R is then equal to dE/dC. The values of R obtained by the two methods are not the same: the second method may even give negative values. III. A calorimetric method has also been used, especially for oscillatory discharges: here the relation of R to C is quite different to what it is in metallic closed circuits. Thus we can only assign an arbitrary meaning to the so-called "resistance" of a gas, and the best plan is to adhere to measurements of E and C and to relations between these which can be empirically determined. D. E. J.

2032. *Hall Effect.* **P. Moretto.** (N. Cimento, 11. pp. 278–290, April, 1900. Paper read before the Società Italiana di Fisica.)—The objects of the experiments described are: (1) To decide if for weak currents the Hall-effect remains proportional to the intensity of current passing through the metallic film; and (2) to decide whether the Hall-effect takes place when the metallic film is traversed by the instantaneous currents of condenser-discharges. The feeble currents employed were measured by a slight modification of Cardani's alkalimetric method [see Abstract No. 1156 (1898)]. The

Hall-effect was studied in the cases of gold- and bismuth-leaves prepared according to Righi's method. Each, in one set of experiments, consisted of a rectangle 15·95 mm. long by 13 mm. wide, one end being bifurcated. On each were three electrodes of tin-foil, A, B, B′, to which conductors were connected. A was connected to a battery of accumulators, and the current divided. Each section was connected to a separate electrolytic meter ; then the two branches rejoined and the current returned to the battery. Each experiment was divided into four stages. The partial currents were measured (1) without any magnetic field ; (2) with the magnetic field exerted ; (3)



with the field reversed ; (4) without any magnetic field. Calling i_1 and i_2 the intensities of the currents in the respective branches when there is no field ; $(i_1 + \alpha_1)$ and $(i_2 - \alpha_2)$ the intensities when the field is in one direction ; and $(i_1 - \beta_1)$ and $(i_2 + \beta_2)$ the intensities when the field is reversed ; it is clear that the current due to Hall's Phenomenon in one case equals $-(\alpha_1 + \alpha_2)$ and in the other $(\beta_1 + \beta_2)$. These two values are not exactly equal, but we may say that the entire variation, $\omega = \frac{1}{2}(\alpha_1 + \alpha_2 + \beta_1 + \beta_2)$. The following results were obtained :—

Strength of field, H, in C.G.S. units.	ω ampere.	$\frac{\omega}{H}$
8,200	0·0000510	150×10^{-10}
9,600	0·0001474	153×10^{-10}
14,930	0·0002087	140×10^{-10}
20,265	0·0002477	122×10^{-10}

It is seen that the ratio ω/H remains practically constant between 8,200 and 9,600, after which there is a rapid diminution with increase of strength of field.

In the case of bismuth, two leaves of different thicknesses were subjected to the same experiment. One was 0·045 mm., the other 0·005 mm. thick. The Hall-effect was approximately inversely proportional to the thickness. Other things being the same the intensity of the effect with bismuth is 5,785 times that with gold.

A series of experiments were made by varying the intensity of the current in the principal circuit, with the result that the effect is found to be approximately proportional to the current down to 0·04 ampere; but for lower intensities the effect is relatively greater. With discharge-currents the Hall-effect is of the same order of magnitude as with continuous currents. A. G.

2033. *Viscosity of Insulating Liquids in Electric Field.* **G. Pacher** and **L. Finazzi.** (N. Cimento, 11. pp. 290–294, April, 1900. Atti del R. Instituto Veneto di Scienze, 59. pp. 389–403.)—The times of flow of a certain quantity of a liquid through the space between two concentric cylinders are noted,

(1) when the liquids form the plates of a charged condenser, (2) when the cylinders are each at the same potential. With water, alcohol, ether, benzole, oil of turpentine, and bisulphide of carbon, there is no appreciable difference between the times; and hence there is practically no difference between the viscosities in the two states. This conclusion is different from the results obtained by Duff and Quincke. A. G.

2034. *A New Coherer.* **Jagadindu Ray.** (Calcutta Univ. Mag. 6. p. 102, Nov., 1899.)—Two magnetised rods are inserted, with unlike poles facing each other, in a block of cork or ebonite. A number of small rings of iron or steel wire connect two of the poles, and the other two form the terminals of the coherer. The current is adjusted until a slight touch produces a marked change of resistance. An incident electric wave causes a similar change, usually a diminution. Decoherence is brought about by tapping. The new coherer is well adapted for lecture experiments. E. E. F.

2035. *Spark-Length of Induction Coil.* **R. Beattie.** (Phil. Mag. 50. pp. 139–148, July, 1900.)—The object of the experiments here described was to examine how the length of the secondary spark depends upon the nature of the primary poles, the rate of break, and the E.M.F. in the primary circuit—(1) with no condenser across the break, (2) with condensers of various capacities across the break. Without the condenser the make-sparks were found to increase with the volts in primary with either platinum or carbon poles. The break-sparks, on the other hand, decreased considerably with platinum poles on increasing the volts in the primary; with carbon poles a slight decrease occurred for quick breaks, but an increase for a slow break. The primary current was always 2·5 amperes. It is noticeable that in certain cases the make-spark was larger than that due to break. The quicker the break the larger the spark in each case. With condensers the results are more complicated. For each kind of pole tried a most suitable capacity could be found which gave a maximum spark-length, this best capacity varying with the nature of the poles. The quickness of break of the several orders tried made no appreciable difference in the spark-length when the primary poles were of platinum; very little difference when they were of copper, but a considerable difference when they were of carbon or zinc. E. H. B.

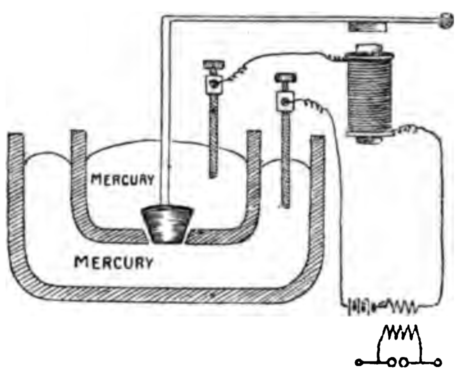
2036. *Spectroscopy of Wehnelt Interrupter.* **E. Hoppe.** (Elektrotechn. Zeitschr. 21. pp. 507–508, June 21, 1900.)—The author observed that when a platinum wire is inserted in a tube containing mercury and used as negative electrode in a Wehnelt interrupter, the mercury is drawn through past the platinum wire when the current is started, unless the wire fits the orifice tightly. A spectroscope, focussed upon the liquid in the neighbourhood of the wire, shows the spectrum of mercury. By substituting solutions of metallic salts for the mercury other metallic spectra may be obtained. The author regards the drawing-through of the liquid as an electrodynamic phenomenon. E. E. F.

2037. *Wehnelt Interrupter on Alternate-Current Circuits.* **G. T. Hanchett.** (Elect. World and Engineer, 35. pp. 899–900, June 16, 1900.)—On an alternating-current circuit of 8,000 alternations per minute, the Wehnelt interrupter operates well, and produces some powerful and brilliant secondary effects. The secondary discharge is not of the striated character that obtains

on direct-current work, and for short distances is yellow, fuzzy and calorific. For long distances it becomes crisp, blue, and snappy, the dividing-line between the two kinds of spark being quite abrupt. In some experiments, as the secondary terminals which were supporting the crisp blue spark were slowly approached there suddenly appeared at a striking distance of about three-quarters of an inch and coincidently with the blue spark a yellow calorific spark which was distinctly separate, and not until the discharge rods were very closely adjacent did the discharges unite with a single calorific spark. There is reason to believe these two discharges were respectively a positive and negative discharge occurring alternately, though to the eye simultaneous.

The interrupter action was quite violent, and the metal plate forming one terminal seemed to be attacked and quickly rendered the solution turbid. This was undoubtedly due to the effect of nascent oxygen, which was generated there to a much greater extent than in direct-current working. In general, it may be stated that the secondary discharges on alternating current Wehnelt interrupter circuits are not as brilliant and are of lesser voltage than in the case of direct currents. E. E. F.

2038. *New Mercury Interrupter.* **E. W. Caldwell.** (Elect. Rev. N.Y. 36. p. 631, June 20, 1900.)—The interruptions are made between two surfaces of mercury instead of between mercury and another metal. Hence surface impurities are avoided, and any mercury vapour formed is recondensed at once.



The construction is shown in the diagram. The separation of the two mercury surfaces is effected by a sort of poppet valve of insulating material driven by an electromagnet in the same circuit. The difficulty lies in obtaining a material which is not destroyed by the sparks. The author suggests lava. E. E. F.

2039. *Resistance of Wehnelt Interrupter.* **C. Heinke.** (Phys. Zeitschr. 1. pp. 334–336, April 28, 1900.)—Commenting on the paper referred to in the following Abstract, the author points out that the Wehnelt interrupter is a "wave-current generator" of the second class, whose resistance varies rapidly within wide limits. In introducing, for practical purposes of calculation, the conception of a mean value, it is necessary to define that conception very accurately. In the Wehnelt interrupter, three different kinds of resistance may be distinguished. The first is the ordinary ohmic resistance. The second is the effective resistance as calculated from the watts consumed and the

effective current intensity. These two kinds are not equal, since the instantaneous values of the current strength and the resistance always change in opposite senses. The third kind of resistance is obtained by dividing the effective E.M.F. between the terminals of the interrupter by the effective current. The quantity denoted by w in Ruhmer's paper is not identical with any of the above resistances, since the effective E.M.F. is not measured at the terminals of the interrupter, but of the interrupter and inductance combined. The two quantities denoted by w in the first and second equation above are therefore not identical. None of the three resistances as defined are constant in the Wehnelt interrupter, as may be proved by measurements with a wattmeter or a calorimeter. E. E. F.

2040. *Resistance of Wehnelt Interrupter.* **E. Ruhmer.** (Phys. Zeitschr. 1. pp. 303–305, April 7, 1900.)—The author investigates the validity of Simon's formula for the period T of a Wehnelt interrupter in terms of the inductance L, the resistance w, and the E.M.F., E., viz. :—

$$T = \frac{3}{2}\frac{L}{w} + \frac{Cw}{E^2}$$

which, combined with Simon's second relation

$$J^2wT = C,$$

gives the following equation for the mean resistance regarded as constant,

$$w^3 = \frac{E^2}{J^2}w - \frac{3}{2}\frac{E^2}{J^2}\frac{L}{T}$$

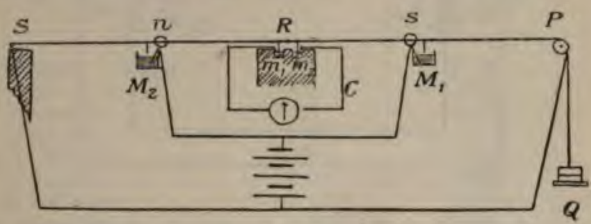
Experiments with three interrupters, whose anode areas were as 1 : 2 : 3, showed that the resistance of one and the same interrupter is not constant, but increases with the inductance and inversely with the current strength. If the surface of the platinum anode is increased or diminished, leaving everything else constant, it is found that with increasing surface the current density decreases. This is due to the influence of the inductance, which ensures that in any number of different interrupters, the frequency solely depends upon the current density. [See also Abstract No. 164 (1900).]
E. E. F.

2041. *Frequency of Liquid Interrupters.* **E. Ruhmer.** (Phys. Zeitschr. 1. pp. 345–347, May 12, 1900.)—The paper, after enumerating methods which have been used for measuring the frequency of the interruptions, describes a dust figure method. A wire hook rests on a brass disc covered with paper which has been treated with shellac and sprinkled with lycopodium. This disc is rotated by clockwork. The hook describes a spiral curve in which dust-heaps occur at every current interruption, the hook being connected with the positive pole of the interrupter and the rotating axle with the negative pole. The interruptions per second are found by means of a speed counter. Photographs of the disc are reproduced, showing well-marked dust-heaps. G. E. A.

2042. *Mechanical Model of a Condenser.* **V. Karpen.** (Soc. Franç. Phys., Bull. 150. pp. 3–4, June 1, 1900.)—Each plate of the condenser is represented by a combination of two wheels gearing into a pinion in such a way that the rotation of the pinion corresponds to the charge of the plate, while the rotations of the wheels correspond to the charges of its faces. The

dielectric is represented by springs which are strained by the rotation of the wheels. Thus the model illustrates the strain set up in the dielectric of a condenser when the condenser is charged and the manner in which the strain is removed during discharge, the discharge being oscillatory if the moments of inertia of the movable parts be large as compared with the frictional resistances. It also illustrates the disruptive discharge, the slow discharge and the residual charge of a condenser. The expression for the energy stored up in it, when "charged," is of the same form as that for the energy stored up in a condenser. W. E. T.

2043. *A String Alternator.* **K. Honda** and **S. Shimizu.** (Amer. Journ. Sci. 10. pp. 64–65, July, 1900.)—Pupin's interrupter, consisting of a wire carrying a current vibrating in a magnetic field, is modified to serve as an alternator. The horizontal wire, SP, vibrates, with a node at R, between the poles *n*, *s*, of an electromagnet. At R the wire SP is separated into two

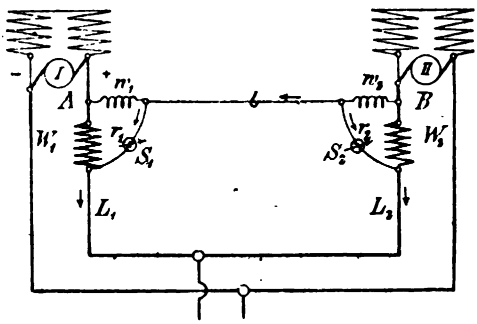


parts, which are only electrically connected through the circuit C. M_1, M_2, m_1, m_2 are mercury cups. If the tension be not small the actual frequency does not differ by more than 1 per cent. from the calculated value, the vibrations ranging from 30 to 1,000 per second. G. E. A.

2044. *Standard Cells.* **W. Jaeger.** (Centralblatt f. Accumulatoren- u. Elementenk. pp. 3–5, Jan. 1; 28–32, Jan. 15; 51–56, Feb. 1; 73–76, Feb. 15; 89–92, March 1, 1900.)—These papers form a short treatise on the subject of primary batteries. The thermodynamics of the cell is first dealt with, the method of calculating the E.M.F. from the heat equivalents of the chemical reactions being given as originally given by Kelvin and then modified by Helmholtz for temperature coefficient. The conditions which a cell must fulfil in order to be a standard of E.M.F. are next considered, and then the different primary batteries are reviewed in the light of these conditions. The Clark and the cadmium cell are the only two which can be regarded as at all standard, and the latter has the great advantages of a very low temperature coefficient and no temperature lag. Full instructions for setting up these cells are given. The cadmium cell as made and patented by Weston contains a solution of cadmium sulphate which is saturated at 4° C. J. B. H.

2045. *Indicating Currents at a Distance.* **C. Michalke** and **O. Martienssen.** (Elektrotechn. Zeitschr. 21. pp. 461–463, June 7, 1900.)—This device is for use in cases where one network is fed by two generating stations arranged at some distance apart, so as to enable it to be determined, at either station, what current is being supplied to the mains at the other station, or for indicating the E.M.F. of distant batteries of constant internal resistance, independently of the magnitude and direction of the charging or discharging current.

This is effected by means of one conductor connecting, *e.g.*, the positive poles of the two stations. After describing two arrangements whereby this can be effected, which arrangements, however, do not give the desired result directly, the authors give the arrangement shown in the figure where J_1 is the current in the conductor L_1, the resistance of which, including the measuring resistance W_1, is R_1; J_2, the current in the conductor L_2, the resistance of which, including the measuring resistance W_2, is R_2; i the current in the conductor l; i_1 that in the resistance w_1; i_2 that in the resistance w_2; c_1 that in the current-indicator S_1; and c_2 that in the current-indicator S_2; r_1 and r_2 are the resistances of the current-indicators S_1, S_2. In order that the current-



indicator at each station shall indicate the current at the other station, the following conditions must be satisfied, viz. :—

$$J_1 W_1 + i_1 w_1 = O, \ i.e., \ J_1 : - i_1 = w : R_1$$

assuming that the resistances R_1 and R_2 are negligible relatively to the resistance w, which is the resistance of l from A to B. Thus $w_1 = w\frac{W_1}{R_1}$ and $w_2 = w\frac{W_2}{R_2}$. The constants of the current-indicators are obtained from the equations—

$$c_1 = J_2 \frac{R_2}{R_1} \cdot \frac{W_1}{r_1 + w_1}$$

$$c_2 = J_1 \frac{R_1}{R_2} \cdot \frac{W_2}{r_2 + w_2}.$$

The conditions for the cases where R_1 R_2 are not negligible and equations for calculating the values of the various resistances are also given, together with a numerical example. C. K. F.

2046. *Commercial Electrical Measuring-Instruments.* **E. S. Shoults.** (Northern Soc. Elect. Engin., Proc. 5. pp. 31–61; Discussion, pp. 61–68, 1899.)—In this paper the author discusses the various forms of commercial instruments on the market. He first deprecates the use of dials of a larger size than 9 inches as he considers that errors due to weight, inertia, and friction become excessive when this size is exceeded. As regards the influence of stray magnetic fields, he finds that instruments of the D'Arsonval type, when enclosed in stout iron cases, are not affected under ordinary conditions. He has obtained very satisfactory results from instruments fitted with the McWhirter shielding device [see Abstract No. 521 (1898)], which consists in replacing the brass cheeks of the main coil of any ordinary electromagnetic instrument by cheeks of iron about ¼ inch thick, and then slipping over the whole bobbin

a tube of iron of like thickness. In one instrument the disturbing effect was reduced from 16 per cent. to 5·9 per cent., and in another from 30 per cent. to 0·75 per cent. The errors introduced by residual magnetism are very small and may be neglected in practice. A Stanley movement was also made using hardened tool steel in place of soft iron, and the results showed that at 70° deflection, the maximum percentage difference between the rising and falling curves was only 1·7 per cent. As regards accuracy, the author pointed out that large temperature errors existed in D'Arsonval type permanent magnet ammeters, having moving coils wound with copper and shunts of some alloy which does not vary in resistance with changes of temperature. Results are given of some experiments made to determine the forces dealt with in certain well-known types of instrument, as follows:—

Type of Instrument.	Watts used in active part.	Torque per watt in grammes at 1 cm. radius.	Deflection in degrees.
Kelvin Balance	70·9	25·19	—
„ Gauge	6·4	0·295	45
Dolivo Voltmeter	0·8	0·187	75
Stanley Voltmeter	1·4	0·139	72
Stanley-McWhirter	1·4	0·195	72
Nalder Voltmeter	0·6	0·415	70
Evershed Voltmeter	1·17	0·184	78
Western Pattern	0·0012	472·00	84

The author also describes an instrument made by the General Electric Company, which can be used either as an ammeter, a voltmeter, or a galvanometer. It consists of a moving coil galvanometer which, when used as a voltmeter, has an external resistance of manganin in series with the moving coil; and when used as an ammeter has a shunt arranged so that the current passes through it, the instrument indicating the fall of potential over this shunt. In discussing alternate-current instruments, the author stated that he found that a shielded bobbin is quite as good as a plain one, provided that the iron is worked at a low induction density and is laminated. An ohmmeter made by the General Electric Company was also described. This instrument consists of a low reading ammeter, arranged so that it can be connected by means of a switch, through a known resistance between either pole of the circuit and earth. As most circuits work at constant voltage, the deflection obtained will be inversely proportional to the earth resistance under test. The new Aron meter is described [see Abstract No. 1954 (1899)]. C. K. F.

2047. *Universal Galvanometer.* **F. Breisig.** (Elektrotechn. Zeitschr. 21. pp. 538–540, June 28, 1900. Paper read before the Elektrotechnische Verein, May 22, 1900.)—The instrument is intended for testing purposes at telegraph stations as a universal galvanometer. It is an improved form of the Siemens apparatus. The circular slate disc, with its peripheral slide-wire, is retained, but the astatic differential arrangement is replaced by differential suspended coils. There is also a very compact scheme of plugs and switches for changing connections for the various tests. A general view of the instrument is given, and a diagram and description of the connections.

R. A.

ALTERNATING CURRENTS AND MAGNETISM.

2048. *Transmission of Polyphase Currents over Long Lines.* **C. E. Guye.** (Archives des Sciences, 9. pp. 532–552, June, 1900.)—A mathematical paper in which the author considers the generalised meanings of the terms "inductance" and "capacity" per unit length of line [see Abstract No. 1308 (1900)], taking first the case of electrostatic equilibrium, then that of steady currents traversing the conductors, and finally that of variable currents. The second part of the paper deals with the case of a symmetrical system of conductors traversed by polyphase currents. A. H.

2049. *Action of Light on Magnetism.* **J. H. Hart.** (Amer. Journ. Sci. 10. pp. 66–73, July, 1900.)—Iron bars prepared by Bidwell's method (Proc. Phys. Soc., London, April, 1889, p. 455) are used, first in verifying Bidwell's experiments. Placed in a field of 400 c.g.s., the bars were kept free from vibration as the magnetising force was withdrawn, and then exposed to the light from an ordinary gas-jet at 6 inches' distance. In every case a decrease of magnetism was observed. The action is concluded to be in general a purely mechanical one, similar to the effect of a blow. Experiments with iron films on glass showed a probable action of polarised light. G. E. A.

2050. *Magnetic Hysteresis in a Rotating Body.* **A. Dina.** (Elettricità, Milan, 19. pp. 324–326, May 26, 1900. Paper read before the R. Istituto Lombardo di Scienze e Lettere, March 29, and April 5.)—Experiments were made to compare the hysteresis loss in a rotating mass of iron with that produced by alternate currents, and by step-by-step cycles. A coil of insulated iron wire was arranged to rotate in the field of a dynamo, and the rise of temperature caused by the heat evolved was found by the increase of resistance of the coil as measured on a Wheatstone bridge. The amount of energy corresponding to a given rise of temperature was determined by observing the latter when a steady current was sent through the coil. The induction was varied from 7,000 to 18,000. Comparing the hysteresis loss thus measured with that found by step-by-step cycles, the former was slightly greater up to $B = 10{,}000$, and then became less, showing at $B = 18{,}000$ a difference of about 9 per cent. This difference agrees with results predicted by Swinburne and Ewing from the molecular theory of magnetism. G. H. B.

REFERENCES.

2051. *Electric Units.* **E. Budde.** (Elect. World and Engineer, 35. pp. 628–629, April 28, 1900.)—With reference to the proposed changes in the system of legalised electromagnetic units [see Abstracts Nos. 1055 and 1056 (1900)] the author objects to such changes on account of commercial and legislative objections. E. E. F.

2052. *Measurement of Phase Differences.* **F. Fontaine.** (Assoc. Ing. Él. Liège, Bull. 11. pp. 51–83, April 20, 1900.)—This is a very complete *résumé* of all known methods of determining the difference of phase between two alternating currents, or between an alternating potential difference and the resulting current in any circuit. The methods dealt with are those of Janet, Puluy, Ferraris, Engelmeyer, Korda, Hess, Arnò, Dobrowolsky, Blakesley, Claude, and Brüger. W. G. R.

2053. *Treatment of Urethral Stricture by Electrolysis.* **F. Lynch.** (Archiv. d'Él. Médicale, 8. pp. 203–205, May, 1900.)—The author reports four cases cured in this way. H. L. J.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

2054. *Solubility of Hydrated Mixed Crystals,* III. **W. Stortenbeker.** (Zeitschr. Phys. Chem. 34. pp. 108–123, July 3, 1900.)—A continuation of previous work on the subject (Zeitschr. Phys. Chem. 17. 643, 1895, and 22. 60, 1897.)—In the present paper it is shown that the mixed crystals of copper-zinc sulphate and of copper-manganese sulphate consist of concentric layers of different composition, the outer layers being richer in copper than the inner. The question is theoretically discussed, and it is concluded that this peculiarity is probably common to all mixed crystals, although the fact can only be definitely proved in favourable cases. N. L.

2055. *Allotropic Forms of Selenium.* **A. P. Saunders.** (Journ. Phys. Chem. 4. pp. 423–513, June, 1900.)—Attempts were made to discover the existence of transition-points between the various modifications of selenium. It was found, however, that the amorphous or vitreous (supercooled liquid) modification (sp. gr. = 4·27) is labile at all temperatures and tends to pass into the stable crystalline grey or metallic variety (sp. gr. = 4·80), although the transformation does not readily occur below 60° or 80°. In contact with certain solvents, however, the amorphous selenium is transformed into the metallic form at ordinary temperatures.

A third modification of selenium is the red crystalline variety (sp. gr. = 4·47), which appears to be intermediate between the two preceding forms. It is produced by the action of certain solvents on the amorphous form and probably has an instable melting-point at 170–180°, when it melts and immediately solidifies in the metallic form. Selenium appears, therefore, to be a monotropic dimorphous substance, like benzophenone, but possessing in addition the property of supercooling until the liquid becomes a vitreous mass with very little tendency to pass into the stable solid modifications.

The paper consists largely of a very full summary of the results of other workers on the physical properties of the different modifications of selenium and contains a bibliography of the subject. T. M. L.

2056. *Heat of Solution of Hydrogen Peroxide.* **de Forcrand.** (Comptes Rendus, 130. pp. 1620–1622, June 11, 1900.)—The author prepares hydrogen peroxide solutions of various strengths by the methods described by Hanriot and Wolffenstein, and determines their heats of dilution with the following results (final state = H_2O_2 + 3 litres H_2O) :—

Percentage of H_2O_2.	Initial State.	Heat of Dilution (Cal.).
35·31	H_2O_2 + 3·46 H_2O	+ 0·071
42·66	„ + 2·53 „	+ 0·093
55·16	„ + 1·54 „	+ 0·099
65·38	„ + 1 „	+ 0·310
85·93	„ + 0·3 „	+ 0·403

On plotting these results the author finds that the curve so obtained comprises two chief portions, namely from 0 to 55·16 per cent., and from 65·38 to 100 per cent., the intermediate part rising steeply and pointing to the existence of a hydrate of the formula H_2O_2 + H_2O. By graphically extrapolating from the above curve the heat of solution of anhydrous peroxide is

found to be + 0·46 Cal. The paper concludes with calculations of the "mean thermal value" of the hydroxyl group, and of the influence exerted on it by C, CH_2, and CH_3, whereby the author hopes to lay the foundations of a theory of acidity. Reference must, however, be made to the original paper for the details of this calculation. F. G. D.

2057. *Heat of Formation of Alloys.* **J. B. Tayler.** (Phil. Mag. 50. pp. 37–43, July, 1900. Read before the Phys. Soc. of London.)—The heat of formation is here determined by measuring the heat of solution in mercury (*a*) of the alloy, and (*b*) of its constituents, and assuming that the products in the two cases are similar. Alloys of lead with tin, bismuth and zinc, and of zinc with tin and mercury were used.

The experimental results are given in tabular form in the paper, and some of them are given below. It is evident from the second column that the alloys contain a small percentage of true compounds, and it may be noted that eutectic alloys (*i.e.*, alloys with lowest melting-point) do not necessarily correspond to the greatest evolution of heat.

Alloy.	Heat of Formation per gramme alloy in calories.	Heat of Formation per gramme molec. weight of compound in calories.	Volts corresponding thereto.	Observed Volta Effect in volts.	Peltier E.M.F. in volts.
Lead-Zinc Eutectic. Zinc 1·6 p.c.	−5·8	−23,800	0·53	0·210 (Ayrton & Perry)	0·0008
Lead-Zinc. Zinc 23·9 p.c.	−3·5	−960	0·02	0·31 (Pellat)	
Lead-Bismuth. Lead 55·6 p.c.	+3·8	+1,400	0·03	...	0·017
Tin-Zinc Eutectic. Zinc 8·3 p.c.	+6·1	+4,800	0·10	0·281 (A. & P.) 0·35 (Pellat)	0·0009
Lead-Tin.					
Tin 90·0 p.c.	+3·9	+8,100	0·18	0·099 (A. & P.)	0·0000
„ 61·8 „ (Eutectic)	+1·9	+1,000	0·02	0·04 scratched (Pellat by difference.)	
„ 21·0 „	−0·8	−450	0·01		
„ 5·0 „	−1·1	−2,600	0·06	0·10 clean. (Pellat by difference.)	
„ 2·0 „	−1·0	−6,500	0·14		

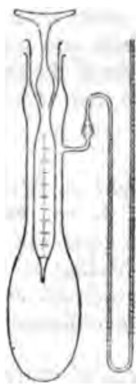
J. B. H.

2058. *Determination of Transition Temperatures.* **H. M. Dawson** and **P. Williams.** (Journ. Phys. Chem. 4. pp. 370–382, May, 1900.)—Transition temperatures have been investigated by the identity method (*i.e.*, the obtaining of identical saturated solutions of two systems transformable into each other), in which the concentration, the vapour-pressure, the solution-pressure, and the difference of potential between the solution and a reversible electrode have severally been taken as the property defining the identity. The authors now propose to use (1) the density, (2) the electrical conductivity, as such

defining properties. By the former they find 32·38° and 59° C. as the transition temperatures for Glauber's salt and manganous chloride respectively, the thermometric method giving 32·379° and 57·9°; the latter method gives 32·5° for Glauber's salt, for which, however, it is not a sensitive method, though it is markedly sensitive for thorium sulphate, for which it indicates 48° C. as the transition-temperature. Since this value differs considerably from 43°, the transition-temperature found by Roozeboom by the solubility method, the authors tested their result by the dilatometer and vapour-density methods, which gave 46·5° and 47·8° respectively. [See also Abstract No. 240 (1900).]

R. E. B.

2059. *Gasometric Apparatus.* **Job.** (Journ. de Physique, 9. pp. 347–349, June, 1900.)—This apparatus is for the purpose of determining the volume of gas absorbed or liberated in a chemical reaction between two bodies, one of which is a liquid. It consists, as will be seen from the accompanying figure, of a glass bulb provided with a manometer in the form of a long, thin tube open at the end and containing mercury or other liquid. In the neck of the bulb fits a ground hollow stopper, which is prolonged so as to form a graduated burette, and is closed by means of a ground stopper fitting in the



narrow part. This ground stopper is also hollow, and is provided, as is also the part of the pipette in which it fits, with a small hole. When the pipette is full of liquid and closed by the stopper the liquid does not flow out until the two small holes are brought into juxtaposition. After the experiment the excess of pressure is read off at the same temperature at which the apparatus was closed. The arrangement may be used in estimating calcium carbide by the evolution of acetylene and in other similar determinations and also in the study of equilibrium phenomena between a liquid and a gaseous phase.

T. H. P.

2060. *Velocity of Formation of Olefines from Aliphatic Iodides.* **S. Brussoff.** (Zeitschr. Phys. Chem. 34. pp. 129–148, July 17, 1900.)—Mainly of chemical interest. The velocity of formation from the chlorides, bromides, and iodides increases in the order indicated, and depends greatly on the number of side-chains and their distance from the halogen atom. N. L.

2061. *Pseudo-Equilibria.* **L. Marchis.** (Journ. de Physique, 9. pp. 326–339, June, 1900.)—The author gives an elementary account, free from mathematical considerations, of the theory of chemical pseudo-equilibria propounded by Duhem. The paper is illustrated by diagrams, and reference

is made to the work of Pelabon on the system H—Se, of Jouniaux on the system H—Ag—Cl, of Gautier and Hélier on the system H—O, and of Joubert on the system P—O. Only a very brief reference is made to Bodenstein's work (Zeit. Phys. Chem. 1899), and no attempt is made to refute his arguments. [See Abstracts Nos. 233 and 234 (1900).] F. G. D.

2062. *Taste and Ionisation of Acid Salts.* **L. Kahlenberg.** (Journ. Phys. Chem. 4. pp. 533–537, June, 1900.)—The fact that the sour taste of acid sodium salts is much more intense than it ought to be according to the assumption that sourness is caused by hydrogen ions only, has been explained by Richards as due to the removal of hydrogen ions by the act of tasting, more ions being then formed and removed and so on; the intensity of the sour taste is thus due to a cumulative effect. The author points out, however, that with an acid like hydrochloric acid a certain minimum initial concentration of hydrogen ions is necessary in order that a sour taste may be experienced, this concentration being slightly greater than N/1000. But in the case of acid sodium malate a solution with only one-fortieth of this concentration of hydrogen ions has a sour taste, and it can hardly be supposed that the organs of taste are capable of storing up hydrogen ions from weak acids or acid salts until their concentration is forty times the original. The author concludes that the sour taste of acids and acid salts is due to the chemical reactiveness they possess by virtue of the presence of hydrogen replaceable by a metal or basic radicle; the more readily this hydrogen is replaceable the more intense is the taste. T. H. P.

2063. *Vapour-Pressure Relations in Mixtures of Two Liquids.* **A. E. Taylor.** (Journ. Phys. Chem. 4. pp. 290–305, April, and 355–369, May, 1900.)—In determining the boiling-point of mixtures of liquids special precautions are necessary if superheating is to be avoided. Garnets mixed with platinum or with silver tetrahedra are especially effective, but even these must be added in large quantities, and their volume must be at least half that of the liquid used.

The boiling-points of mixtures of water and acetone in different proportions have been investigated over a wide range of pressures, and the composition of the distillate from nine different mixtures has been determined at two different pressures. The results are given in tables and are represented graphically by means of p-T curves for the series of mixtures, as well as by isotherms and isobars. T. M. L.

2064. *Thermodynamics of Normal Elements.* **E. Cohen.** (Zeitschr. Phys. Chem. 34. pp. 62–68, July 3, 1900.)—In calculating the E.M.F. of a Clark cell from the thermo-chemical data and the temperature coefficient of the cell, it is not sufficient merely to allow for the displacement of mercury by zinc in the sulphate, for the zinc sulphate separates from the saturated solution with $7H_2O$. It is now shown that a further correction is needed to allow for the fact that the $7H_2O$ is taken from a saturated solution and causes the separation of a larger quantity of zinc sulphate than that which is formed by the dissolving of the zinc. The heat change calculated from the electrical data is 81,490 cal. The displacement of mercury by zinc represents 55,090 cal., or, when corrected for the separation of the zinc sulphate as $ZnSO_4 . 7H_2O$, 77,780 cal.; and the correction now made for the removal of water from the solution and separation of a further quantity of zinc sulphate brings the value

up to 81,127 cal., a value which agrees very closely with that calculated from the E.M.F. of the cell. Similar considerations apply to the hydrate $ZnSO_4 . 6H_2O$, which is stable above 39° C. T. M. L.

2065. *The Weston Cell as a Transition Cell and as a Standard of E.M.F.* **H. T. Barnes.** (Journ. Phys. Chem. 4. pp. 339–348, May, 1900.)—Kohnstamm and Cohen [see Abstract No. 1059 (1898)] have shown by means of solubility-determinations and other methods that an inversion-point occurs at 15° in the temperature curve of cadmium sulphate, and this is now used to explain the irregular behaviour of the Weston cell observed by Jaeger and Wachsmuth (Wied. Ann. 59, 575, 1896). Between 15° and 40° C. the E.M.F. of a number of cells was found to be accurately represented by the formula $E_t = E_{15} - 0{\cdot}086\ (t - 15°)$, but below 15° each cell shows a different temperature coefficient, depending on the rate at which the transformation takes place. In two cells the curve above 15° was continued on cooling below that temperature to about 2°, when a rapid change from the labile to the stable form took place.

The ratio $\frac{\text{Clark } 15°}{\text{Cadmium } 20°}$ was found to be 1·40658, a result practically identical with the recent value, 1·40663, determined by Kahle (Wied. Ann. 67, 35, 1899). T. M. L.

2066. *Ionisation Constant of Azoimide (Hydrazoic Acid).* **C. A. West.** (Chem. Soc., Journ. 77. and 78. pp. 705–707, May, 1900.)—For sodium hydrazoate, μ_∞ has the value 109, whence the value for hydrazoic acid is 385. Conductivity measurements with the acid give the following results :—

v	μ	m	k
10	5·38	0·01397	0·0000198
100	15·98	0·0415	0·0000180
1000	45·97	0·1194	0·0000166

From the rate of inversion of cane-sugar by the acid the value of k is found to be 0·0000186. The avidity of hydrazoic acid is hence slightly greater than that of acetic acid ($k = 0{\cdot}0000180$). T. H. P.

2067. *Formation of Ozone by the Brush Discharge in Oxygen.* **E. Warburg.** (Preuss. Akad. Wiss. Berlin, Sitzb. 33. and 34. pp. 712–721, July 5, 1900.)—The author supposes that the brush discharge besides having an ozonising effect on oxygen has a deozonising effect on ozone, and this combined with the small spontaneous deozonising effect controls the percentage of ozone which can be obtained in oxygen by the brush discharge. Supposing that the ozonising and deozonising effects are proportional respectively to the number of gramme molecules of oxygen (n_2) and of ozone (n_1) present in the mixture, the increase in the number of molecules of ozone is given by—

$$dn_1 = b \, . \, \frac{n_2}{v}\, dt - (a + a')\, \frac{n_1}{v}\, dt,$$

where a, a' and b are constants, and v the volume of the vessel. The constant "a" refers to the deozonising effect of the discharge, and "a'" to the spontaneous deozonisation ; "a'" is found to be very small compared with "a." The latter is found to vary very considerably with temperature, being three times as great at 93° as it is at 0° C. The constant b is very little affected by temperature, so that as the temperature increases the

ozonising effect of the discharge remains constant, while the deozonising effect increases very rapidly, thus diminishing the percentage of ozone present.

The value of "*b*" for the negative discharge is almost three times as great as it is for the positive discharge, while the value of "*a*" is nearly the same for both. The temperature influence is also approximately the same for both.

J. B. H.

2068. *Electro-chemical Equivalent of Carbon.* **S. Skinner.** (Cambridge Phil. Soc., Proc. 10. pp. 261–267, May 7, 1900.)—The author electrolysed potassium permanganate, using a carbon anode. The gas evolved contained carbon dioxide in quantities varying from 77 to 86 per cent. The permanganic acid appears to be chiefly reformed. In the case of electrolysis of water, sulphuric acid, and potassium permanganate, with a carbon anode, the author suggests that the primary products are $C(OH)_4$, $C(HSO_4)_4$, and $C(MnO_4)_4$ respectively.

W. R. C.

2069. *Electrolytic Determinations and Separations.* **L. G. Kollock.** (Chem. News, 81. pp. 220–222, May 11; 231–233, May 18; 244–246, May 25; and pp. 271–273, June 8, 1900. From the Amer. Chem. Soc., Journ. 21. No. 10.)—In this paper, which does not admit of suitable abstraction, the author gives the results of an extensive series of experiments made to determine the conditions as regards current density, voltage, &c., under which cadmium, silver, mercury, gold, copper, bismuth, and iron may be estimated electrolytically both in pure solutions and when mixed with other metals.

T. H. P.

2070. *Electrolytic Deposition of Metals from Non-Aqueous Solutions.* **L. Kahlenberg.** (Journ. Phys. Chem. 4. pp. 349–354, May, 1900.)—In connection with previous researches on the potential differences between metals and non-aqueous solutions of their salts [see Abstract No. 545 (1900)] it was necessary to ascertain whether Faraday's law held for such solutions, and a series of electrolytic determinations were made with solutions of silver nitrate in pyridine, aniline, benzonitrile, quinoline, and acetone, of lead nitrate in pyridine, and of antimony chloride in methyl alcohol. The electrolyses were carried out at about 20° between a platinum kathode and an anode of the same metal whose salt the solutions contained, and the amount of metal deposited was compared with that deposited in a silver voltameter in circuit. Apart from minor discrepancies due to secondary reactions, Faraday's law was found to hold.

A compact deposit of silver may also be obtained from a pyridine solution using two platinum electrodes; the E.M.F. should be about 3 volts and the kathode current density about 0·3 ampere per 100 sq. cms. Under certain conditions, moreover, good results are obtained from solutions of silver nitrate in mixtures of water with pyridine, aniline, or acetone. N. L.

2071. *Electrolysis of Sodium Chloride.* **C. G. L. Wolf.** (Journ. Phys. Chem. 4. pp. 200–206, March, 1900.)—An apparatus is described which permits of variation of conditions as quickly as possible, and with a minimum of rearrangement; it is well adapted for lecture demonstrations, and the effect of adding alkalies, acids, or salts may be shown without interrupting the current. It consists of a U-tube having a central limb for the insertion of a stirring apparatus, each of the two side limbs being fitted with a thermometer, a platinum electrode, and a tube for conveying the gases evolved to a measuring tube. A diagram is given in the paper. Details are

also given of the electrolysis in this apparatus of a solution containing 300 grammes of sodium chloride, and 1·8 grammes of potassium chromate per litre, using a current of about 1 ampere, the anode and kathode current densities being respectively 0·14 and 6·66 amperes per sq. cm. Under these conditions the average efficiency was about 80 per cent., and in a little over seven hours 12·7 per cent. of the sodium chloride was oxidised to chlorate. Stress is laid on the importance of efficient stirring, and the maintenance of a constant temperature if a high efficiency is to be attained. N. L.

2072. *Electrolytic Preparation of Fluorine in a Copper Vessel.* **H. Moissan.** (Chem. News, 81. p. 218, May 11, 1900; from the Soc. Chim., Bull. 23. No. 8).—When a platinum cell is used for the electrolysis of a hydrofluoric acid solution of potassium, the rapid wearing away of both the cell and the electrodes makes the apparatus very expensive. To determine whether it is possible to replace the platinum by another metal, the author placed samples of various metallic wires at the bottom of the electrolytic vessel, the preparation of fluorine being then carried out as usual. It is found that of all metals, with the exception of platinum, copper is the least attacked under these conditions. An electrolytic cell of copper for the preparation of fluorine gives good results, but the electrodes must be of platinum; the copper probably becomes coated with a layer of insoluble badly conducting copper fluoride, and in the case of the electrodes such a deposit would greatly diminish or even stop the current. T. H. P.

2073. *Electrolysis of Nitrogen Hydrides and Hydroxylamine.* **E. C. Szarvasy.** (Chem. Soc., Journ. 77. and 78. pp. 603–608, May, 1900.)—A preliminary account of experiments on the electrolysis of ammonia, hydrazine, azoimide, and hydroxylamine and their salts at different current densities, temperatures, and concentrations. The three nitrogen hydrides were found to yield their nitrogen and hydrogen in the theoretical proportions, when sufficiently high current densities were employed, even at the ordinary temperature. Attempts to electrolyse hydroxylamine were unsuccessful, owing to spontaneous decomposition occurring; when hydroxylamine sulphate is used, secondary reactions take place, ammonia being formed at the kathode and oxygen compounds of nitrogen at the anode. N. L.

2074. *Progress of Aluminium.* **J. W. Richards.** (Frank. Inst., Journ. 149. pp. 451–459, June, 1900.)—A summarised version of an address delivered on April 18, 1900. Referring to the question of cost, the lecturer stated that every item of manufacture had been reduced since the introduction of the electrolytic process. The *lowest* cost per lb. is now probably about 20 cents, while the selling price is 25 cents in Europe and 30 cents in U.S.A. Details of the latest methods of production cannot be given, owing to the reluctance of manufacturers to publish them. As evidence of the comparative cheapness of aluminium, the lecturer stated that 1 dozen thimbles of the new metal could be bought in Philadelphia for 5 cents. The metal in these weighs only ¼ oz., and would cost the manufacturer of the thimbles about 1 cent. The present comparative cost for *equal volumes* of the following metals were :—

Aluminium (⅓ lb.)	11 cents.
Brass (1 lb.)	15 cents.
Copper (1 lb.)	17 cents.
Tin	30 cents.

Five per cent. copper, nickel or manganese or 30 per cent. zinc, added to aluminium yielded strong light alloys.

The Delaware Metal Refining Company of Philadelphia are producing an alloy of sp. gr. 3·1, as rigid and strong as ordinary bronze or gun metal.

Referring to the use of aluminium for cooking-vessels, the lecturer stated that an aluminium kettle had been in use in his home for seven years, and beyond an internal brown coating of oxide which seemed to protect the metal beneath, it had not suffered any change by continuous use. In America aluminium is superseding zinc for fruit-jar caps, as, though more expensive, it is less harmful if acted on by the fruit-juice.

As regards the use of aluminium for lithographic printing, the author stated that thirty firms in U.S.A., and about forty-five in Europe are already using the new metal, chiefly on rotary presses, and a great development may be looked for in this direction.

The use of aluminium for electrical purposes is progressing rapidly. In 1899, 500 tons of aluminium in wire or rod form had been used for long-distance transmission, or for trolley lines in U.S.A.

The new metal can be beaten out into leaf only $\frac{1}{10000}$ inch in thickness, and this leaf had entirely displaced silver-leaf in decoration work. The leaf can also be ground to a powder, and used either for printing or painting when mixed with a suitable vehicle.

The lecturer closed his address with a reference to the use of aluminium for reducing purposes. Tissier, and Wahl and Greene, had first experimented with granulated and powdered aluminium for this purpose; and the latter two experimenters obtained chromium and manganese free from carbon in this way. Goldschmidt had introduced improvements in this process of reduction, and his method is now in use at Essen, in Germany, and at Philadelphia, for production of ferro-chromium and ferro-manganese. These alloys are used in the manufacture of armour-plate steel. J. B. C. K.

REFERENCE.

2075. *Electro-chemistry.* **F. M. Perkin.** (Nature, 62. pp. 138–139, June 7, 1900.)—An article describing the progress in obtaining the non-metals and their compounds, and organic products, by electrolytic methods. Among the former, hydrogen, oxygen, ozone, artificial diamonds (Majorana's process), carborudum, the alkalies, bleaching powder, hypochlorites, chlorates, and white lead, are very briefly dealt with. Among organic compounds, iodoform, chloral, and aniline and its oxidation products are touched upon. The article closes with a brief description of the electrolytic method for printing aniline-black and indigo-blue patterns upon cloth, and with a plea for greater attention to the study of electro-chemistry by chemists in this country. J. B. C. K

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

2076. *Steam Turbines and Superheated Steam.* **R. H. Thurston.** (Science, 11. pp. 972–973, June 29, 1900.)—It is found that there is a considerable gain in both the efficiency and capacity of a steam turbine by the use of superheated steam. This is contrary to expectation, since the internal surfaces of a steam turbine are in a steady state and not subject to alterations of temperature such as must obtain in all cylinder and piston engines. There is consequently none of the usual initial condensation loss, and it is chiefly to reduce the waste from this cause that superheated steam is employed with ordinary engines. With the steam turbine the only advantage to be expected is the small increase of thermodynamic efficiency due to the augmented range of temperature. In some experiments on a 10-H.P. Laval turbine at Sibley College, this gain would amount theoretically to about one-tenth of 1 per cent. for each 3° F. of superheat, whereas the actual results give a gain of 1 per cent. in efficiency for each 3° F., and a doubling of the capacity of the machine by the use of superheat through 37° F. The gain in efficiency is substantially proportional to the amount of superheat, and seems to be due to the elimination of the loss by friction caused by moisture in the steam as it passes through the turbine. Further investigation is in progress. H. R. C.

2077. *Increasing the Efficiency of Steam Engines.* **E. C. de Segundo.** (Elect. Rev. 46. pp. 1048–1049, June 22, 1900.)—Professor E. Josse, of the Royal Technical High School, Charlottenburg, has made experiments on a steam engine with which is combined an auxiliary engine utilising the heat contained in the exhaust steam; the invention of G. Behrend and Zimmermann. The heat contained in the waste steam is used to evaporate a liquid having a lower boiling-point than water, a solution of sulphurous acid having been chosen after many experiments; it is said to be cheap, and to lubricate the inner working surfaces of the machinery without corroding them. The steam engine has a stroke of 20 inches, and a speed of 41 r.p.m. From the low-pressure cylinder the exhaust steam passes into a surface condenser in which the cooling medium is sulphurous acid. This is immediately decomposed by the heat of the exhaust steam, sulphur dioxide gas is liberated and passes over into the cylinder of the auxiliary engine. This auxiliary engine has a cylinder 12 inches diameter, stroke 20 inches, r.p.m. 77. After passing through the cylinder the sulphur dioxide vapour enters a surface condenser where it is condensed to liquid by cold water flowing around the tubes as in an ordinary steam plant. The steam engine developed 34 I.H.P. with a steam consumption of 18·96 lbs. per I.H.P. hour. The auxiliary engine indicated 19 H.P.; reducing the steam consumption to 12·13 lbs. per I.H.P. hour. A. S.

2078. *Steam Jets* **W. Rosenhain.** (Inst. Civ. Engin., Proc. 140. pp. 199–219, June, 1900.)—The reaction of the jet is measured directly by equipoising, and the rate of flow of the steam is deduced from a separate experiment at the same pressure by condensing and weighing the discharge. Several different nozzles were used, including a sharp-edged orifice and

tapering tubes of various proportions. As a result of the experiments it is stated that to give the greatest kinetic energy per lb. of steam the best nozzle is, for pressures below 80 lbs. per sq. in., a sharp-edged orifice, and for pressures above that, a very slightly expanding cone. Several diagrams of results are given. H. R. C.

GAS AND OIL ENGINES.

2079. *Crossley 350-H.P. Gas Engine.* (Engineer, 90. p. 68, July 20, 1900.)—The largest gas engine yet built by Crossley Brothers has two horizontal cylinders 26 inches diameter by 36 inches stroke, placed end to end on opposite sides of the crankshaft; the normal speed is 150 r.p.m. The engine is designed to work with Mond producer gas, and drives a dynamo direct by means of a flexible coupling. The output is 2,250 amperes at 110 volts, equal to 332 E.H.P. The engine has to run day and night for long periods without stopping.

The very heavy fly-wheel is built up in halves by a novel method of making the joints. It consists of dovetailed clips of good quality steel, machined, and carefully fitted, having taper of $\frac{1}{8}$ inch to 1 foot, and driven on to corresponding machined joggles. The ends of the clips are also fitted to under-cut surfaces on the rim which prevent them from springing when strained. The internal sections are bolted together. There are thus definite stresses in the material which binds the sections together.

The speed is regulated by a centrifugal governor, varying the quantity of Mond gas mixing with the air in the charges of constant volume, there being no cut-out until the load on the engine falls below half the normal.

The ends of the cylinder water-jackets have detachable covers. The exhaust valves are fitted in detachable boxes instead of being cast on the cylinders. An equilibrating arrangement has been adopted which facilitates the opening of the large exhaust valves and relieves the working parts of undue strain. The exhaust valves and spindles are hollow, with water circulation through them to keep them cool and for efficient lubrication.

W. R.

2080. *Valves of Internal Combustion Engines.* **J. D. Roots.** (Engineer, 90. pp. 49–51, July 20, 1900.)—The exhaust valve is opened positively, that is by mechanical means actuated by the crankshaft of the engine. Only in small engines, as used for the propulsion of vehicles, the charge admission valve is opened automatically by atmospheric pressure. The valves are closed by a spring which produces a blow on the seating. The strength of the spring should only be a very slight amount in excess of that necessary to close the valve. According to present practice the best angle for the seating of the mushroom valve is 45°.

Common forms of valve are shown, suitable for charge, air, and exhaust valves; and their defects discussed. The slot, to enable the valve to be ground in, may be cut across the top or in a projection. The width of the seating should be from one-eighth in small valves to one-seventh of the outside diameter in large ones. In a spirit engine the exhaust valve becomes more corroded than in gas and oil engines, where it lasts for nearly double the time before requiring regrinding. High-speed valves should be made of mild steel.

The valve-box and spindle-guide should be in one casting, so that when the guide is bored out accurately, and the seating turned true with the bore, the valve remains true after years of wear and repeated regrinding. If made

separate or insufficiently water-jacketed, the exhaust valve-box and spindle-guide may so warp that the valve rests upon a small part of one side of the seat, causing leakage. In a large high-speed gas engine the inlet valve-box as well as the exhaust should be water-jacketed.

In an engine running at 750 r.p.m., the valve begins to open when the piston has traversed four-fifths of the working stroke, remains open during the whole exhaust stroke, and closes just *after* the dead point. In large engines of 200 r.p.m. the exhaust valve opens at from six-sevenths to seven-eighths of the working stroke. This valve and opening mechanism must be made to withstand the total pressure of 35 to 50 lbs. per square inch of valve area at the time of opening.

Formulæ are given for the proper area and lift of valves. The range of lift should be from $\frac{3}{32}$ to $\frac{3}{16}$ inch. The higher the speed and the smaller the valve the less will be the lift; and the converse holds true, the slower the speed and the larger the valve the greater the lift given within this limit.

W. R.

AUTOMOBILISM.

2081. *Acetylene as Motive Power for Vehicles.* **E. C. Oliver.** (Horseless Age, 6. pp. 12–14, June 20, 1900.)—In the manufacture of calcium carbide one H.P. hour produces 0·3 lb. of carbide of good quality, or about 7,000 H.P. hours per ton. At Niagara, taking 18 dollars per electrical H.P. per year, the price of calcium carbide is 75 to 80 dollars per ton. Good commercial carbide gives nearly 5 cubic feet of acetylene gas per pound, when decomposed by water, and in the reaction the heat evolved amounts to 900 B.Th.U.

In the various types of gas generators, either the water is fed drop by drop on the carbide, or the carbide is added in small lumps to a large quantity of water which takes up the heat generated and keeps the carbide cool. Acetylene gas polymerizes at 600° C., forming benzol, and by interaction naphthalene and other compounds with tarry products. Pure acetylene has an ether-like odour, and the strong, unpleasant smell of the commercial product is due to the impurities, phosphoretted hydrogen and sulphuretted hydrogen. Acetylene may be liquefied at its critical temperature, 97° F., by a pressure of 68 atmospheres, or at 68° F. by 42·8 atmospheres. In this state one volume of liquid acetylene will produce 340 volumes of free gas. The liquid is of specific gravity 0·4, water being 1; and one volume at 32° F. expands to 1·24 volumes at 96° F. It may be fired by a spark or incandescent wire and detonates with violence like an explosive. At 59° F. and atmospheric pressure, acetone (C_3H_6O) absorbs 25 times, and at 12 atmospheres 300 times, its volume of acetylene gas. This mixture is explosive at pressures above 28 up to 142 lbs. per square inch. Acetylene alone will not explode until the pressure is 1·05 atmosphere, but above this pressure it is violently explosive, consequently it should not be kept under a pressure of more than a few inches of water. At atmospheric pressure a mixture in the proportion 1 of acetylene gas to 1 of air, burns with sooty flame, and 9 to 12 of air to 1 of acetylene gas gives strongest explosion. Even 25 volumes of air to 1 of acetylene gives combustion without explosion. P. Ravel states that the temperature required to explode this gas is about 900°, and the temperature of explosion reaches 7,200° F.; whereas mixture of coal-gas and air ignites at 1,100° F.

With a 2-H.P. motor he obtained one H.P.-hour on 6·35 cubic feet of

acetylene, using a mixture 15 of air to 1 of gas. The acetylene gave 2·1 times the power of coal-gas. He could not use more than 5 per cent. of gas in the mixture with high compression, as the explosions became violent and the pressure was extremely great, yet it fell off at once and expansion was not sustained.

The points to be noted regarding the behaviour of the gas are: (1) The low ignition temperature; (2) the great velocity of flame propagation; (3) the high temperature of combustion; (4) great energy of explosion; (5) the wide range of its explosive mixtures. To avoid premature ignition the engine cylinder must be kept at a low temperature, and then the cooling action of the walls would greatly lessen the effective pressure of expansion. The shock by explosion would necessitate greater area of bearings, and stiffer construction. At present acetylene is more expensive than gasoline, and the acetylene motor, with reciprocating piston, subject to great wear and tear, is in the experimental stage, where it is likely to spend a considerable time, though one may be built which will prove not only successful but popular. W. R.

2082. *Acetylene and Alcohol for Motors.* **P. M. Heldt.** (Horseless Age, 6. pp. 16–17, June 20, 1900.)—*Acetylene* gas has a calorific value of 12,200 calories per kg., and gasoline 11,360 calories per kg. One kilogramme of calcium carbide yields 300 litres of acetylene at atmospheric pressure, or nearly 5 cubic feet per lb. In a stationary engine the carbide for 1 H.P. hour weighs at least 500 grammes, and requires 273 grammes of water, making a total weight of 773 grammes; whereas in an engine of the same size, the gasoline required weighs only 267 to 334 grammes, and costs less than acetylene. It is very difficult to regulate the production of acetylene on automobiles to suit the change of road surface.

Alcohol.—The use of alcohol in internal combustion motors has been tried by French automobilists. The heat energy of a kilogramme of pure alcohol is 7,183 calories. Practical tests, of a gasoline motor with alcohol, give a reduction of motive power of about one-third. In a trial run between Paris and Chantilly, a distance of 42 km., with a light vehicle weighing 400 kilos. (880 lbs.) and carrying two passengers, the consumption of alcohol was 19 litres in 4 hours 8 minutes. With gasoline it would have taken 11 litres. The cost of alcohol fuel for this trip was found to be about three times as high as for gasoline. The run was made with ordinary pure alcohol, and not the denaturated alcohol, of which it is supposed the price can be reduced by relieving it of the taxes. Comparing the prices in the United States, the chances of calcium carbide and alcohol being applied to the propulsion of motor vehicles in place of gasoline are very small. W. R.

2083. *Acetylene and Gasoline for Motors.* **L. Berger.** (Horseless Age, 6. p. 20, June 20, 1900.)—This is a theoretical comparison of the results from acetylene and gasoline exploded in the cylinder of an automobile motor.

Acetylene, C_2H_2, has a specific volume at 0° C. and 760 mm. of mercury, of 860 litres, or 0·860 cubic metre per kg. Berthelot finds that 1 kg. of acetylene by decomposition gives 2,235 calories, and by complete combustion with 9·281 cubic metres of air yields 9,490 calories, or a total of 11,725 calories per kg. On explosion in a closed vessel, if the initial pressure be denoted by 1, that after explosion will be 17·2. The corresponding rise in temperature is 5,226° C., and the volume of gases on cooling to their initial temperature and pressure is $\frac{3}{3 \cdot 5} = 0 \cdot 85$ of their original volume before explosion.

Gasoline, of density 0·700, is chiefly hexane, C_6H_{14}; and the specific volume of its vapour, at 0° C. and 760 mm. of mercury, is 0·260 cubic metre per kg., and vapour density 2·975, air being 1. One kilogramme of gasoline vapour requires for complete combustion 10·667 cubic metres of air. This mixture, 18·4 volumes of liquid gasoline to 100,000 of air, or 2·4 per cent. of vapour at 0° C., gives 11,086 calories per kg. of gasoline. The rise of temperature is 4,191° C.; and the factor for increase of pressure is 20·2; and the resulting volume, when cooled, is $\frac{13}{10 \cdot 5}$, or 1·24 times the original. Here the proportion of gasoline vapour to air is 1 to 41 at 0° C., while for acetylene it is as 1 to 11.

In France, the experiments by G. Richard on a Benz motor with acetylene have shown that the explosion is rapid and violent, and the regulation of the mixture is difficult. The initial decomposition of the gas results in a deposit of carbon on the cylinder walls with loss of heating power. In spite of the troubles in gasoline carburetion by change of vapour pressure due to change of temperature at the carburetter, the conclusion is that better results are to be expected with gasoline than with acetylene in automobile motors. W. R.

REFERENCE.

2084. *Feed-water Heaters*, II. **J. F. Hobart.** (Amer. Electn. 12. pp. 354–356, July, 1900.)—A continuation of previous articles on this subject [*cf.* Abstract No. 1551 (1900)] the apparatus here described and illustrated being the Baragwanath, the Jacobs, the Jackson, the Wainwright, the Kensington, the Cochrane, and the Webster heaters. F. J. R.

GENERAL ELECTRICAL ENGINEERING.

2085. *Connecting up Electric Batteries.* **F. Vogel.** (Centralblatt f. Accumulatoren- u. Elementenk. 1. pp. 2–3, Jan. 1, 1900.)—Reference having been made to some results obtained by F. Auerbach (Elektrotech. Zeitschr. 1887, p. 66), the author finds the least number k of cells required for sending a definite current i through a given external resistance w_a, to be as follows, viz. :—

$$k = \frac{4i^2ww_a}{E^2}\,;\; n = \frac{2iw_a}{E}\,;\; m = \frac{2iw}{E}$$

where w = the internal resistance and E = the E.M.F. of each cell ; n = the number of cells in series, and m = the number of parallel groups of cells. The efficiency of this arrangement is 50 per cent. The case in which the amount of material used in generating current is to be as small as possible is next considered. The equations obtained show that for this purpose as many groups as possible should be put in parallel. When the costs of installation and working are both taken into consideration, the following results are obtained, viz. :—

$$k = \frac{iw_a . iw}{E^2}\left\{2 + \frac{\frac{Eit\Sigma(ag)}{iw} + 2\frac{Ap}{100}}{\sqrt{\left(\frac{Ap}{100}\right)^2 + \frac{Ap}{100}\cdot\frac{Eit\Sigma(ag)}{iw}}}\right\}$$

and—

$$n = \frac{iw_a}{E}\left\{1 + \sqrt{\frac{\frac{Ap}{100}}{\frac{Ap}{100} + \frac{Et\Sigma(ag)}{w}}}\right\}$$

where A = the prime cost of one element ; p = the percentage amortisation per annum ; t = the number of time-units of working per annum ; g_1, g_2 are the corresponding electro-chemical-equivalents of the substances consumed (*e.g.*, zinc) ; and a_1, a_2 are the costs of unit-quantity of the several substances.

C. K. F.

2086. *Aluminium-Magnesium Alloys.* **R. H. Thurston.** (Science, 11. pp. 783–785, May 18, 1900.)—The author points out that in 1893 an account had been published of investigations on the "newly-discovered" series of alloys. The average breaking strength of magnesium is 22,250 lbs. per square inch, average elastic limit 8,870 lbs. per square inch, average elongation 2·8 per cent. The density of the metal is only two-thirds that of aluminium, but it has one-half more tensile strength. The addition of magnesium to aluminium steadily reduces ductility, until at one-third magnesium and two-thirds aluminium, the alloy is as brittle as glass. The volatility of the lighter metal is an element of difficulty in its use in alloys, especially with those which have a high temperature of fusion. The extreme range of the tenacities of magnesium was between 20,000 and 30,000 lbs. per square inch, corresponding to a suspension of 30,000 to 40,000 feet ; this is the equivalent of steel of about 100,000 lbs. tenacity. Could the cast portions of the steam engine be made in this material,

their weights would be reduced about one-half; it is therefore possible that magnesium with its high tenacity and great lightness may prove the coming material for work in which these qualities are important. A. S.

2087. *Voltage Regulator for Three-phase Circuits.* **G. Zweifel.** (Ind. Élect. 9. pp. 281–288, July, 1900.)—The use of an ordinary reactance or choking coil for purposes of regulation is attended with the following disadvantages: (1) The limits within which regulation is possible are very narrow if the current is variable. Thus, a coil which allows of a 10 per cent. regulation with the normal current is only capable of a 5 per cent. regulation at half-load, and has practically no effect at light load. (2) The coil introduces a phase difference (thus reducing the power factor) which may become considerable if regulation within wide limits is required. Both these disadvantages are done away with in the apparatus described by the author, which is intended for three-phase circuits, and consists practically of two induction motors whose rotors (which carry the primary or inducing winding) are mounted on the same shaft, and are not allowed to rotate, but may be displaced, by means of

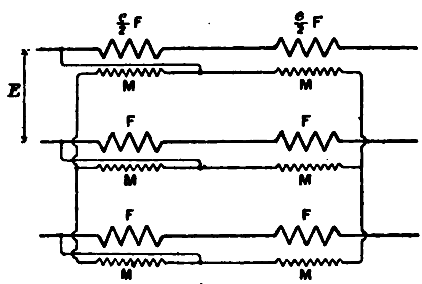


Fig. 1.

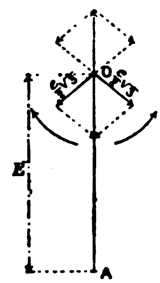
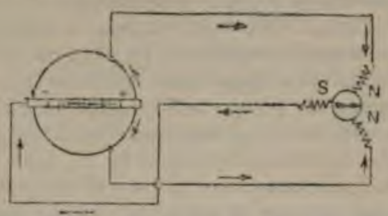


Fig. 2.

suitable gearing, through any desired angle. Fig. 1 shows the arrangement of connections, FF denoting the fixed windings of the regulator, which carry the main currents, and in each of which an E.M.F. of fixed magnitude $e/2$ is induced by the movable windings MM, which are supplied at a constant P.D. (E), being in connection with the generator terminals or 'bus bars. Fig. 2 is an E.M.F diagram. The phase of the induced E.M.F.'s, $e/2$, may be varied by altering the position of the movable inducing windings. From fig. 2 it is evident that the limits of regulation are given by $E \pm e$, and that the added or subtracted E.M.F. is always in phase with the generator P.D. Further, on account of the double arrangement of circuits, there is no resultant torque on the movable portion of the apparatus, the two equal and opposite torques acting on the two sets of windings merely producing a torsion of the shaft. A. H.

2088. *Electric Dial Ship-Telegraph.* **F. Querengässer.** (Elektrotechn. Zeitschr. 21. pp. 602–604, July 19, 1900. Paper read before the 8. Jahresversammlung des Verbandes Deutsch. Elektrotechn. at Kiel.)—The principle of the arrangement will be understood by reference to the accompanying sketch, which shows the connections used in the earlier form of this instrument. A closed circular resistance coil is supplied, by means of the signalling arm, with current at two diametrically opposite points. Three points in the coil, spaced 120° apart, are connected, by means of three wires, with the three coils of the receiving instrument. These three coils

produce a rotating field as the signalling arm is turned, and the magnet which carries the pointer moving over the dial of the receiving instrument takes up a certain position for each position of the signalling arm. The following improvements have recently been introduced into this instrument. In the earlier form the currents did not follow the sine law, with the result that variations in the E.M.F. caused changes in the position of the magnet in the receiving instrument. In the more modern form, the



resistance coil is subdivided into sections of unequal resistance, and current is supplied to it at two fixed points; while the three line wires from the receiving instrument are connected to an arm provided with three contacts spaced 120° apart; by this means the currents may be made to follow the sine law accurately, and there is no uncertainty regarding the position of the pointer in the receiving instrument. A further improvement consists in the use of a copper cylinder for damping the oscillations of the magnet. A. H.

2089. *Electrical Conductors and Dust.* **A. A. Campbell Swinton.** (Electrician, 45. pp. 17–18, April 27, 1900.)—The author noticed that some of the flexible leads to lights in his office collected dust and became dirty much more rapidly than others, and he discovered further that the switch in circuit with those leads which collected the dust rapidly was in the negative side; whereas the switch of the clean cord circuits was in the positive side. The phenomenon is due to the fact that the negative main always tends to earth itself. For example, on the Westminster Company's system a test showed that from the negative there are 30 volts to earth, while from the positive there are 170 volts to earth. Consequently, in the case of lights having a switch in the negative side, the flexible cord is at a potential of 170 volts whenever the lights are not on, and dust is attracted much more than when the switch is in the positive. E. D. P.

2090. *Electrical Conductors and Dust.* **F. G. Baily.** (Electrician, 45. pp. 604–605, Aug. 10, 1900.)—Referring to the paper dealt with in the preceding Abstract, the author states that of two conductors, one positive and the other equally negative, the positive attracts dust slightly more than the negative. In the case of switches, an earthed cover is recommended as a preventive against deposit of dust on the adjacent wall. W. H. E.

2091. *Krizik's Electric Block System.* **J. Guillaume.** (Écl. Électr. 24. pp. 5–16, July 7, 1900.)—This is a new system shown at the Paris Exhibition in the Austrian section. A battery of accumulators is required at each station. For charging them a trolley is employed carrying a motor, worked by benzine, and a dynamo, and this can be, of course, run from station to station as required. When in use for charging, one pair of the trolley wheels is raised off the line, and by being coupled to the motor shaft acts as a fly-

wheel. The electric semaphore can have its lever attached to any existing railway signal. It is operated by an electric motor within a cast-iron case. Weights and restoring springs are dispensed with. The motor is reversible in movement by change in the direction of the current, and when moved one way raises, and the other lowers, the signal arm. The movement operates also a commutator which enables the current to be reversed when an appropriate key is used at the distant station, or at the signal-box connected with the semaphore. But the reversal of the motor so as to alter the position of the arm cannot be effected without the co-operation of the train, when the arm is to "danger." When the train has passed the semaphore, one of the rails is slightly deflected by the weight of the engine, or waggon, and caused to complete the necessary circuit to raise the semaphore behind, or an insulated rail can be used, and the required contact then takes place through the wheels and axle to earth on the other side of the line. So that with this system there is no alteration needed nor attachments necessitated in existing rolling stock. The block instrument at the station or signal-box in rear is operated by the contacts in the semaphore case (which are changed by the motor), so that, when the arm goes up, the visual signal of the instrument at the last protected point becomes red, and when the arm falls, becomes white, thus blocking and unblocking the section. The current is only flowing while these signals are working, so that there is no waste. For the exact mode of operation the diagrams with the description should be referred to. The electro-motor is four-pole with inducing bobbins, carefully protected from damp. The change of direction of rotation is obtained in one of the following ways : The inductor can have two windings opposed the one to the other, the current being sent through one to signal "danger," and through the other for "line clear" ; or, using one winding on the inductor, send, for one class of signal, the current through this, and the induced coils as a motor in series, and for the other class adopt the parallel arrangement, regulating the movement if necessary by a resistance between this circuit and earth. E. O. W.

2092. *Swing Bridges at Northwich.* **J. A. Saner.** (Inst. Civ. Engin., Proc. 140. pp. 72–84 ; Discussion, pp. 85–108, June, 1900.)—The Northwich Bridge, a plate girder structure of 90 feet span, had caused, owing to the subsidence of the district, great inconvenience to the river traffic through the constantly decreasing headway. The average loss of headway over a period of sixteen years had been 4½ inches per annum. Parliamentary powers were granted for the erection of two swing bridges, some distance apart, so that one bridge could always be available for road traffic. The form of bridge adopted by the author consists essentially of (1) a pair of bowstring lattice girders carrying the roadway ; (2) a circular pontoon placed under the centre of gravity of the superstructure, rigidly connected thereto so as to be always submerged in the river, and capable of being turned with the superstructure ; (3) a group of cast-iron screw piles surrounding, but clear of, the pontoon, and carrying a gridiron girder, which in turn carries the bottom roller path. The upward buoyancy of the pontoon is less than the aggregate weight of the superstructure, by a quantity which can be varied at will within certain limits. For example, if the total weight of the superstructure and pontoon is 303 tons, and the normal buoyancy of the pontoon 255 tons, the weight resting on the rollers and piles is 48 tons. In the event of adjustment being required, therefore, only 48 tons have to be dealt with, and even this can be reduced to 28 tons by emptying the upper part of the pontoon.

The constructional details of the bridge are described at length. The motive power used for operating the bridge is electricity, taking from the Northwich Electric Supply Company at 440 volts. The gates for the town bridge are moved by two 4-B.H.P. motors, controlled by a switch placed near the cabin door. For the turning gear, the power is transmitted from the machinery house to the bridge by means of two 1½-inch wire ropes wound opposite ways round a vertical barrel, and fixed to the circular girder of the bridge. The navigation bridge had up to the time of writing been opened and closed 155 times; as a rule, the gates can be closed, wedges withdrawn, and bridge turned in 1½ minutes. The electric current used for the complete operations of opening and closing is ¼ unit, costing 1d. The electric machinery, &c., cost £1,100 for each bridge. A. S.

REFERENCES.

2093. *Lightning Conductors.* **A. della Riccia.** (Elettricità, Milan, 19. pp. 146–151, March 10, 1900. From the *Rivista di Artiglieria e Genio*, 1900.)—The author gives instructions for erecting lightning-conductors on buildings of various descriptions, with special reference to powder magazines. G. H. B.

2094. *Electric Cranes.* (Elect. Rev. 45. pp. 803–807, Nov. 17, 845–847, Nov. 24, 1899; 46. pp. 57–60, Jan. 12, 427–428, March 16; 47. pp. 167–168, Aug. 3, and 212–214, Aug. 10, 1900.)—Various forms and their application.

2095. *Standard Specifications for Iron and Steel.* (Mech. Eng. 5. pp. 795–797, June 9; 838–840, June 16; and 891–893, June 23, 1900.)—The tentative specifications prepared by the American Section of the International Association are here published; they will be fully discussed later on by the American engineering societies before being adopted. The specifications and methods of testing prescribed refer to—(1) Structural steel for bridges and ships, (2) steel for rails, (3) steel castings, (4) steel forgings, (5) boiler plate and rivet steel, (6) steel axles, (7) steel tyres, and (8) wrought iron.

2096. *Direct-connected Water-wheels and Generators.* **F. C. Perkins.** (West. Electn. 26. pp. 234–235, April 14, 1900.)

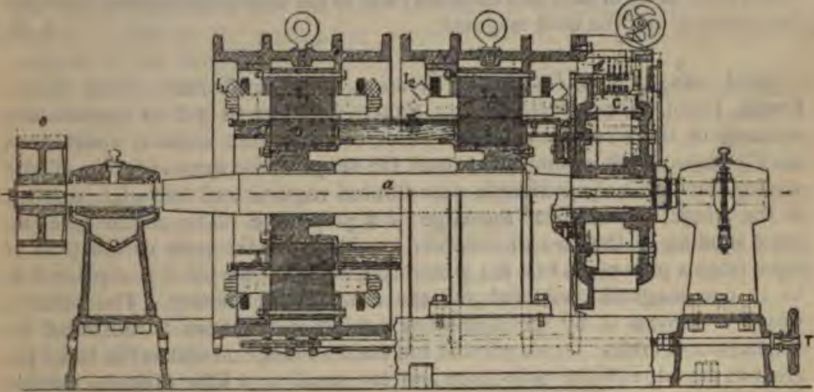
2097. *E. P. Storage Battery.* **H. S. Martin.** (Elect. World and Engineer, 35. pp. 635–636, April 28, 1900.)—An illustrated article giving general particulars of the design and capabilities of this cell. E. J. W.

2098. *Electrical Progress.* **A. W. Heaviside.** (Inst. Elect. Engin., Journ. 29. pp. 900–924, July, 1900.)—An inaugural address, delivered before the Newcastle section and mainly of historical and local interest.

2099. *Lightning Conductors.* **K. Strecker.** (Elektrotechn. Zeitschr. 21. pp. 583–584; Discussion, pp. 584–589, July 12, 1900.)—In 1894 a committee was appointed by the Elektrotechnische Verein to establish a set of rules for the erection of lightning conductors. The paper is a report of a meeting of the Elektrotechnische Verein at which certain proposed rules were read and discussed. The text of the rules is not given, and many references to them in the discussion are therefore unintelligible. Weinhold gave interesting statistics as to the number of protected and unprotected buildings struck by lightning in different parts of Germany, and as to the amount of damage done. The rules were reserved for further consideration. G. H. B.

GENERATORS, MOTORS, AND TRANSFORMERS.

2100. *Grammont Alternator with Hulin and Leblanc Compensating Exciter.* **J. L. Routin.** (Ind. Élect. 9. pp. 249–255, June 25, 1900. See also Electrician, 45. pp. 844–848, Sept. 28, 1900.)—An illustrated description is given of the 600 kw. three-phase alternator exhibited by A. Grammont at the Paris Exhibition. The rotating part of the three-phaser is an inductor wheel with 64 radial poles on its circumference, which makes 93·75 revolutions per minute. The frequency of the alternating current is therefore 50. The stationary part is star wound, and the potential difference between the terminals is 2,400 volts. On a non-inductive load the electrical efficiency is 95 per cent., and when the power factor is 0·7 the efficiency is 93 per cent. A special feature of this alternator is the compensating exciter used. The exciter is geared to the shaft of the alternator by a toothed wheel and pinion, but when the alternator is working the effect of the gearing is to prevent the



armature of the exciter from going too fast, work being done on the shaft by the exciter. The armature of the exciter is not unlike the armature of a multipolar direct current dynamo, and has two cores, D, E. It is subjected to the action of two independent rotating magnetic fields s_1, s_2. The stator s_1 is placed as a shunt across the alternator terminals, and the stator s_2 is in series with the armature windings. Two stators are necessary, as it is essential that the resultant rotating magnetic field in which the armature of the exciter revolves should always be proportioned to the resultant magnetic field of the three-phaser. There are three pairs of poles on the stators, and six pairs of brushes on the commutator of the armature. These brushes collect direct current for the inductor circuit of the three-phaser ; and, owing to the design of the winding and the angle at which the stators are fixed relatively to one another, no adjustment of the brushes is necessary whatever the load or the power-factor may be. The two stators also regulate so as to do away with the necessity of an adjustable resistance, and so the machine is self-regulating at all loads and power-factors. The author gives a full explanation of the theory, and he also gives diagrams of the winding of the exciter. He gives the following equation to determine the speed of the

armature of the exciter in order that direct current may be taken from its commutator with fixed brushes :—

$$N = \frac{f}{n + k}$$

where n = the number of pairs of poles of the stators,
k = the number of pairs of brushes,
f = the frequency of the alternating current,
N = the number of turns the armature makes per second.

In the above equation the armature and the rotating magnetic field are supposed to revolve in the same direction. If they revolved in opposite directions we should have to write $-k$ for k. In the Hutin and Leblanc exciter they rotate in the same direction, and in the case under consideration $n = 3$, $k = 6$, and $f = 50$, hence N is $\frac{50}{9}$, and the armature must rotate 333 times per minute. The author states that the principle of this compensating exciter, although quite accurate enough for practical work, is not absolutely correct. In order to be exact, the self-inductance of the armature circuit would need to be always in a constant ratio to the mutual inductance between the armature and the field magnets. A. R.

2101. *Air-gap and Interpolar Induction.* **F. W. Carter.** (Inst. Elect. Engin., Journ. 29. pp. 925–933, July, 1900.)—In order to get an approximate estimate of the strength of the field at the armature surface, electricians usually make rough assumptions about the shape of the lines of force. These assumptions are only justifiable over limited regions, and fail when applied to the fringe of lines near the edge of a pole-piece. The author gives an exact solution of the two dimensional problems of the path of the lines of force from a pole-piece to a flat armature when the pole-piece is supposed to be at one magnetic potential and the armature at another. The solution which is arrived at by the method of conjugate functions is illustrated by diagrams and tables. It shows that the usual assumption makes the force too great at the edge of the pole-piece and too small at a little distance outside the edge. He also gives an exact solution by the same method of the magnetic problem presented by two unlike rectangular poles and a straight armature. If we suppose the poles to be increased in breadth by a length x until the total breadth multiplied by the maximum value of the flux density will give the total flux, then—

$$\lambda = \frac{x}{g} = 0{\cdot}72 \log\left(\frac{1}{4} + \frac{c^2}{4g^2}\right) + \frac{1}{90}\left(\frac{c}{g} \tan^{-1}\frac{g}{c}\right),$$

where $2c$ is the distance between the poles and g is the length of the air-gap. In the case when c equals $4g$ then λ equals 1·07, a value very much smaller than that obtained (1·76) by Hawkins and Wightman on p. 449 of the same volume of the Journ. of the Inst. of Elect. Engin. A. R.

2102. *Converters for Tramway Sub-stations.* **A. C. Eborall.** (Tram. Rly. World, 9. pp. 326–328, July, 1900.)—An important article dealing with the advantages and disadvantages of rotary converters and motor generators for tramway substations. Converters must be reliable and efficient, and also able to work perfectly in parallel, not only one machine with another, but *one* substation with another. So far in Great Britain all tramway installations

have followed the lead of the States simply because up to the present American contractors have been given the work. The author thinks that in future it would be wiser to take a broader view of the questions involved.

The most striking feature of a rotary converter substation is its complication. Transformers must be inserted between the high pressure lines reducing the voltage to 330, and there is also the switch gear required on the two sides of each rotary; for although they can be started up from the continuous current side, yet it is absolutely necessary for each rotary to be capable of starting up from the three-phase side in case direct current supply is not available. Usually one of the following methods has to be arranged :—

(*a*) A starting set is installed in each sub-station, consisting of a 330-volt three-phase motor coupled to a shunt dynamo, the output of the set being about 7½ per cent. of that of the largest rotary. For starting, all that has to be done is to use the direct current produced by this set to start any rotary from its direct current side. The adjustment of speed necessary for synchronising is easily made by means of the starting resistance and the shunt regulator of the rotary.

(*b*) An induction motor is direct coupled to each rotary for starting up. This will have an output equal to 7 to 10 per cent. of the full load output of the rotary in question, and the chief objection to the method lies in the fact that it is difficult to synchronise properly. It is, however, the standard method of the Westinghouse Company.

(*c*) All rotary converters are constructed either with solid pole-pieces, or else with heavy short-circuited copper straps wound round the polar extremities. It becomes possible, therefore, to start a rotary from the three-phase side as an induction motor by merely switching on current, and this method is used by the General Electric Co. (U.S.A.) for most of their plants, including the Central London Railway.

If the rotary converter is started up from the three-phase side then a pole indicator has to be placed on each D. C. panel to indicate the pole at which the rotary has synchronised. If it should be found to be the wrong one (it is purely a matter of chance) the operation has to be repeated until the polarity of the direct current side is right. Hunting is another trouble very commonly met with in rotaries, especially if the angular velocity of the engines varies more than 0·2 per cent. It is increased if there is much drop on the transformers and cables, and a slight displacement of the brushes on the direct current side may start a group of rotaries hunting, accompanied by violent sparking.

To assist parallel running, "Amortisseurs" are sometimes used; they consist of copper bands embedded in the pole-pieces and short circuited individually. If, however, the pole-pieces of the rotaries are solid and of sufficiently massive design, they will to a large extent take the place of these damping coils.

The design of the rotary converter is not flexible, because in order to keep the speed within reasonable limits either the frequency has to be low or the number of poles very large. A frequency of 25 to 30 cycles is usually chosen; and it is only on account of the small armature reaction (due to the neutralising action of the two sides) that it is possible to operate such machines satisfactorily in spite of the excessive number of field poles.

Over-compounding is generally arranged for by compounding the rotary in the usual manner, and also having a set of choking coils between the slip rings and the low-pressure side of transformers. At no load the field of the rotary is slightly under excited, and due to this and the choking coils the

changes in the resistance and reactance of the line on the overload capacity of the motor. A similar diagram is next constructed for the power developed by the generator, and the total efficiency of transmission is thereby determined. The second part of the paper deals with the effect of variable armature reaction, and with the hunting of synchronous motors and converters, as influenced by the transmission line. A. H.

2108. *Electric Mains at Cheltenham.* **H. Kilgour.** (Northern Soc. Elect. Engin., Proc. 5. pp. 99–112 ; Discussion, pp. 112–114, 1899.)—The generating station is 2,000 yards away from the principal substation, near the centre of the town, which is connected by radiating feeders to other substations, whence minor feeders run to more remote substations, where the transformation takes place from 2,000 volts to 200 or 100 for the distributors. All cables, except for services, are Callender's concentric, insulated with bitumenised fibre, and these have proved very satisfactory. They are mostly armoured, and are laid either direct in the ground or in wooden troughs filled with bitumen, according to the nature of the soil. As a further protection, a layer of bricks is in most cases placed above them. In a few principal streets unarmoured cables have been used, which are drawn into conduits composed of cement concrete with bitumenised paper ducts. The feeders are 37/16, 19/16 ; and 19/18 for arc lighting. The distributors are 37/12, 37/15, and 19/14. Some faults occurred at first in the 19/20 cables for arc lighting, owing to the fact that the number of wires in the outer conductor was not sufficient to completely surround the inner insulation. In such a conductor it was found that if any single wire parted, *e.g.*, at a factory joint, sparking occurred at the contact and eventually caused a fault. Also there was a special liability to mechanical injury in the case of these conductors.

Breakdowns at first occurred in some of the 650-watt transformers placed in the bases of the arc lamp posts. The cause appears to have been damp, and the transformers are now dried by sending current through them at low pressure for about a week, pots of calcium chloride being inserted through the fuse doors and all openings sealed up. The calcium chloride is changed from time to time. Short lead-covered cables are connected to the terminals of each transformer before it is subjected to the above treatment, and thus there is no occasion to open the case in the open air when fixing. In substations the transformers are mostly run with their top covers loose.

In localising faults in the mains, Murray's loop test is almost invariably used. The two portions into which the inner is divided at the fault, together with the cable used for connecting, form one pair of arms of the bridge, the other pair consisting of box resistances. Trouble due to faults and fault-finding is minimised by extensive sectionising of both high and low pressure mains.

The construction of the substations is described in some detail. W. H. E.

2109. *Power Supply by Single-phase Motors.* **T. P. Wilmshurst.** (Elect. Engin. 25. pp. 909–911 ; Discussion, pp. 913–914, June 29, 1900. Paper read before the Municipal Electrical Association, June 21.)—The author reviews the various objections to single-phase motors, pointing out that some are fallacious and others can be removed by proper arrangements. Efficiency tables and curves are given.

Discussion. **S. Z. de Ferranti** advocated the use of single-phase motors, and referred to the value of condensers in improving the power factor. **S. E. Fedden** cited instances where these motors had failed to give satisfaction.

C. Langdon-Davies and **R. C. Quin** pointed out that single-phase motors could not be efficiently operated by alternators giving irregular E.M.F. waves. **W. B. Esson** stated that two-phase machinery cost but little more than single-phase in construction. A. H. A.

2110. *Maintenance of Motors and Starting Switch Gear.* **C. A. L. Prüsmann.** (Elect. Engin. 25. pp. 911-913; Discussion, pp. 913-914, June 29, 1900. Paper read before the Municipal Electrical Association, June 21.)—Motors let out on hire seldom give trouble, but starting switches are as yet unsatisfactory. Liquid resistances with glycerine in the dashpots were tried at Bradford, but were too much affected by changes of temperature; oil dashpots also gave trouble, but air dashpots proved successful. Metallic resistance switches failed through sparking at the contacts. Compound motors were better than shunt-wound machines for cranes, taking a smaller starting current. Shunt motors were satisfactory on steady loads with simple slow-motion starters; no benefit was derived from automatic release devices. For loads subject to severe fluctuations, however, the overload release was indispensable. Motors below 3 B.H.P. cost more to maintain than the larger sizes; spur and belt gearing were practically equal in this respect. Open motors were much more subject to damage than the enclosed type. Injury to commutators was chiefly due to inefficient starters and bad foundations. The cost of maintenance is on the whole insignificant compared with the advantages of a motor load. A. H. A.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

2111. *Electricity in Steel Works.* (Elect. World and Engineer, 36. pp. 49-52, July 14, 1900.)—Electric power transmission is used in the Ohio works of the National Steel Company for very severe duties. Two immense travelling cranes, spanning the ore stock yard, are driven each by two 130 H.P. motors coupled together; these are geared by friction clutches to the various motions. The motors are provided with a weak shunt winding in addition to the main series coils to prevent excessive racing at light loads. Each traveller is capable of handling 1,750 tons of ore per day of ten hours. The waggons conveying the ore from the yard to the bins near the furnaces are all electrically driven, collecting current from two heavy copper trolley-wires running alongside the tracks. From the bins other electric waggons take the ore to the skips, which are hauled to the top of the furnaces by electrical winches. The skips are capable of lifting 16,000 lbs. of ore each, and are hauled to a height of 196 feet in thirty seconds; they are driven by motors of 275 H.P., provided with specially designed automatic controllers which govern the acceleration of the skips and stop them at exactly the right place. Numerous cranes, tables, drill presses, &c., are driven by motors, as well as a 125 H.P. cold saw and a 65 H.P. pig-casting machine. The generating plant consists of two 550 kw. dynamos, working at 250 volts pressure, and driven by compound engines of 1,400 H.P. each. Steam is supplied by a battery of boilers fired with blast-furnace gas. For lighting purposes inverted rotary converters are employed, giving two-phase 50-period alternating currents, which are transformed up to 2,000 volts for distribution. The pressure is controlled by regulators on the switchboards, as the ratio of conversion from direct current is invariable. A. H. A.

2112. *Polyphase Distributing System of the Metropolitan Street Railway Company of New York City.* **J. E. Woodbridge.** (Elect. World and

Engineer, 35. pp. 782–784, May 26, and 859–861, June 9, 1900.)—The first of these two articles is the seventh of a series [see Abstract No. 1372 (1900)], and deals with the substation high-tension circuits—of which a complete diagram is given—and also the six-phase connections to the rotary converters.

Six phases are adopted in order to reduce the copper losses in the rotary armatures because, having no field distortion, the capacity of rotary converters is determined solely by their heating limit and commutating ability. Any means of reducing the heating therefore correspondingly increases the number of kilowatts which a given machine will convert, provided there is sufficient field strength to reverse the currents in the armature coils as the commutator segments pass under the brushes. Steinmetz has shown that a machine which will deliver 100 kw. without overheating when driven mechanically as a generator, will deliver 131 kw. with the same temperature rise when run as a three-phase rotary converter, and 194 kw. when run as a six-phase rotary, other conditions remaining the same. This is allowing for the internal losses of the converter and assuming that the impressed E.M.F. is in phase with the counter E.M.F. of the machine. If wattless currents are not carefully balanced or are used for purposes of regulation the output falls off somewhat. Assuming, for example, that a wattless component amounting to 30 per cent. of the total alternating current input of the machine is drawn in, the same 100 kw. generator will deliver 122 kw. as a three-phase and 167 kw. as a six-phase rotary. In addition to the reduction of the heating the six-phase arrangement distributes the heating much more uniformly round the armature.

The six phases are obtained from the three-phase step-down transformers, which are of the usual single-phase type and three in number, but have each two electrically independent secondaries. These six secondaries are connected up in two separate deltas, so that the rotary will still continue to work even if one transformer becomes crippled. The six collector rings are tapped to six points per pair of poles in the armature winding.

In the eighth article, particulars are given of the rotary converters and their switch gear, &c. The rotaries are 14-pole machines of 990 kw. output, but are able to give 100 per cent. overload for short intervals. The armature has 24 slots per pole, 4 bars per slot, and 48 coils and commutator segments per pole. The fields are compound wound, but up to the present the series coils have been cut out of service, as it has been found that the regulation is so very good, partly owing to the large generating capacity of the system, that the series fields and reactances are not needed. The batteries absorb momentary fluctuations of load, and there is no difficulty in working with them whilst the rotaries continue to be worked as shunt machines.

To reduce any tendency to hunt, copper tongues are inserted under the pole-tips, the eddy currents in which and in the solid steel of the poles, check any tendency of the pole flux to sweep from tip to tip. Oscillators, or end-play devices, are fitted to prevent the brushes from wearing tracks in the commutator and collector rings. Each rotary weighs 45 tons, of which the armature is 16 tons.

The following are the efficiencies: Double full load, 96·8 per cent.; full load, 96·0 per cent.; half load, 93·6 per cent. The step-down transformers give an efficiency of 98 per cent. under full load, and allowing 1½ per cent. loss in the high-tension feeders from the generating station to the substations, and a further loss of ½ per cent. in the substation for the blowers, reactive coils, motor generators, air-pumps, &c., it will be seen that the arrangement gives an all-day efficiency of over 90 per cent. between the

switchboard of the generating station and the direct-current switchboards of the substation.

Particulars are given of the special switching gear on the direct-current switchboards. E. K. S.

2113. *Electric Traction on the London Metropolitan-District Railway.* (Electrician, 45. pp. 163-166, May 25, 1900. Also Electrical Engineer, May 25, 1900.)—In February, 1899, the Associated Metropolitan and District Railway Companies voted £20,000 for the electrical equipment of 5,000 feet of line between Earl's Court and High Street Kensington stations. The engineers, J. Wolfe Barry and W. H. Preece, were required to carry out the work on the permanent way without any interference with the running of the ordinary trains and without any electric current passing through the permanent way or subsoil, lest such should interfere with the signalling arrangements. In accordance with these requirements it became necessary to adopt an insulated return, and to do the whole of the construction work in the few midnight hours when the trains were not running. The electrical work was placed in the hands of Siemens Bros. & Co. The electrical conductors, of inverted channel steel, weigh 75 lbs. per yard, and are carried on double petticoat insulators, the jar being taken by a piece of leather. At points and crossings the continuity of the electrical rails had to be broken, but the gap is in no case so wide that contact is not made in front before it is broken in the rear of the train, which is 245 feet long. The bonding is by copper strip hydraulically riveted. There are two positive and two negative feeders, lead-covered and armoured. The power house is of a temporary character and contains two Belliss Siemens sets and two Babcock-Wilcox boilers. The engines are 300 I.H.P. at 380 r.p.m., and the dynamos give 385 amperes at 550 volts. The boilers are each capable of evaporating 9,000 lbs. per hour for short periods.

There is only one train, by Brown, Marshall & Co., and it requires current for about 3 mins. in 20 mins. It has a motor car at each end, but only one is used at a time. In the event of this type of train being adopted on the Inner Circle it would of course only want one motor car, because the trains always move in the same direction. The train carries 312 passengers. The weight is : four coaches, 72 tons; two motor-cars, 90 tons; passengers, 20 tons. Each motor carriage has four four-pole 26 × 25 Siemens motors, series wound, with armatures built on the axles. Each motor develops a normal drawbar pull of 4,000 lbs., the wheels being 47 inches diameter, and the maximum power about 200 H.P.

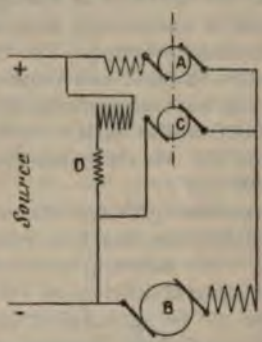
The series parallel controller provides twelve arrangements of motors. There are no short-circuit notches, but it is possible to reverse the motors whilst the train is running. The throwing of the motors against the train is not intended to be used in general practice, all the braking being done by a "Standard" air brake, the air being supplied by an electric three-throw pump, which also supplies air for the whistles and sanding gear.

Current is collected from the conductors by fourteen (seven on each side) cast-iron shoes suspended from the bogeys by insulated bolts. The springs are adjusted so that the bearing pressure is about 10 lbs. When fully loaded the train has started on a 1 in 43 gradient—a feat which an ordinary steam locomotive was unable to perform when hauling a similar load. Owing to the simplicity of the driving arrangements it has been found unnecessary to employ specially trained drivers. Maximum speeds of thirty-eight to thirty-nine miles an hour have been reached. E. K. S.

ELECTRIC TRACTION AND AUTOMOBILISM.

2114. *Electric Canal Haulage.* (Tram. Rly. World, 9. pp. 294–297, July, 1900.)—A system devised by L. Gérard has been installed on the important canal between Brussels and Charleroi, 50 miles in length. The present power station is at Oisquercq, 16½ miles from Brussels, and contains boilers and engines of 450 H.P. in all, driving three-phase alternators by cotton belts. Current is supplied at 6,000 volts pressure to the feeders, which are carried overhead at a height of 36 feet on three-bell insulators. A secondary three-phase line, working at 600 volts, is carried on the same poles at a height of 18 feet, and a 36 kw. transformer is placed in a substation every three miles. Along the towpath runs a four-wheeled tractor, fitted with a three-phase motor of 5 H.P. nominally, but capable of working up to 20 H.P. if necessary. The tractor weighs nearly 2 tons, and measures 7 ft. 9 in. long by 3 ft. 5 in. wide. It is provided with a clutch arrangement for coupling either to the driving axle or to a conical winch for use when a powerful effort is required. The current is collected by a triple trolley, weighing about 1¾ lbs. Each tractor runs over a certain section, drawing five boats, each laden with 10 tons, at a speed of 2½ miles per hour. At meeting-places, either the tow-ropes or the trolleys are exchanged. Besides providing for haulage, the system is used for lighting villages at night, and for supplying power to factories ; 250 H.P. has been applied for, and 1,300 lamps are in use. The article includes illustrations of the apparatus used. A. H. A.

2115. *Solignac Compensator for Regulating Traction Motors.* **J. Reyval.** (Écl. Électr. 24. pp. 154–158, July 28, 1900.)—Large losses are incurred by the frequent starting of tramcars, and by running at low speeds. The Solignac compensator is used by the Société des Voitures Électriques to reduce this waste of energy. The compensator consists of a series-wound motor, A, coupled in series with the main motor, B, and driving a small dynamo, C, whose armature is connected in shunt with the terminals of the latter. The field of the dynamo is excited from the source of energy, and is regulated by a rheostat, D. At the moment of starting, the motor A rapidly runs up to



full speed ; the field of the dynamo C is excited, and the armature supplies current to the main motor B, the result being that the power supplied by the source is only half what it would be if a regulating resistance were used in the usual way. As the speed of the car and of the motor B increases, that of A and C diminishes, until the compensator becomes unnecessary and can be cut out of circuit. If it is desired to run at a low speed, however, the field of the dynamo is weakened and the compensator left in operation.

Curves are given showing the economy of power effected. In the case of a vehicle driven by a 6-H.P. motor, and carrying a battery weighing 1,100 lbs., with a rheostat weighing 66 lbs., by replacing the latter with a compensator of 132 lbs. weight, the battery may be lightened to the extent of 385 lbs. The system is equally applicable to trolley cars. A. H. A.

ELECTRIC LAMPS AND LIGHTING.

2116. *Manufacture of Glow-Lamps without Caps.* **J. A. Montpellier.** (Électricien, 20. pp. 7–9, July 7, 1900.)—The author draws attention to the defects of the ordinary bayonet caps for lamps, and describes a device invented by Hollub, in which no plaster is used. The bulb of the lamp terminates in a button furnished with two small projections, upon which are mounted the contact plates, soldered to the platinum leading-in wires. A brass tubular sheath, slit at one end so as to take a springy seat on the neck of the bulb, and provided with pins to fit the bayonet socket, is buttoned on the glass projections, being held in place by a slotted plate. By this means short circuits in the cap are obviated and the process of manufacture cheapened. A. H. A.

2117. *Bremer Arc Lamp.* **W. Wedding.** (Elektrotechn. Zeitschr. 21. pp. 546–549, July 5, 1900. Paper read at the 8th annual meeting of the Verband Deutscher Elektrotechniker at Kiel.)—In this lamp the carbons are arranged horizontally, and the arc is deflected downwards by electromagnetic means. The positive carbon, in direct-current lamps, contains a compound of calcium. Photometric tests have been carried out, and the following advantages are claimed for this lamp: (1) Increased efficiency, amounting to two or three times that of ordinary arcs; (2) improved distribution of the light; (3) better colour. Details are withheld. W. H. E.

2118. *Arc Lamps on 220-volt Circuits.* **W. Mathiesen.** (Elektrotechn. Zeitschr. 21. pp. 589–591, July 12, 1900. Paper read before the Leipzig Elektrotechnische Gesellschaft.)—The paper describes the various methods adopted by the firm of Körting and Mathiesen for running 1, 2, 3, 4, 5, and 6 arc lamps in series on a 220-volt continuous current circuit. The automatic device which each lamp contains for substituting a resistance when the lamp ceases to work is explained by diagrams. For a series of three lamps the firm makes a special double lamp containing two arcs, so that six arcs are in series on the circuit. For a series of two lamps enclosed arcs are used, but it is admitted that the efficiency is not much greater than when two open arcs are run in series with a resistance. For one lamp, an enclosed arc taking 140 volts is used; the arc is about 8 mm. in length, and gives a very violet-coloured light. G. H. B.

REFERENCES.

2119. *Stansstad-Engelberg Electric Railway.* (Elect. Engin. 25. pp. 523–526, April 13, and 561–565, April 20, 1900.)—These articles comprise a detailed description of the locomotives, rack-way, generating plant, &c., of this line which is operated by multiphase currents generated by turbine-driven alternators. (See also 1899, Abstract No. 1100.) E. H. C.-H.

2120. *Electricity Supply for Small Towns.* **C. S. Vesey Brown.** (Elect. Engin. 25. pp. 878–880, June 22, 1900. Paper read before the Municipal Electrical Association.)

TELEGRAPHY AND TELEPHONY.

2121. *Munier's Multiple Telegraphs.* **Munier.** (Écl. Électr. 24. pp. 81–91, July 21, 1900.)—The inventor's first system described in 1886 and 1887 comprised a "distributor" and "compensator" for working the Hughes' type-printer in multiple. The "distributor" was a wheel divided into as many sectors as there were receivers, theoretically. Each sector contained 28 contacts connected electrically to 28 keys of a board. As the wheel revolved each sector was presented in turn to receive and re-transmit a current from the key pressed. The speed of the Hughes had to be maintained at from 120 to 140 turns, so that the inventor had to devise a method by which his transmitter would travel exactly n times as fast, n being the number of the receivers to be operated. His first thought was to provide 28 contacts in each consecutive sector of his distributor, the operator being guided by a metronome as to the right moment to press any key, and to use in the receiver a part of the type-wheel only, proportional to the number of receivers being worked, *e.g.*, the wheel would have all the characters assembled on one-fourth of the periphery if there were four receivers. However, this device would have necessitated radical alterations in existing apparatus, besides being liable to inconveniences in function as well as in effecting ordinary combinations, so that Munier employed his "compensator" in connection with the Hughes. Its mode of working and details of parts are fully described and illustrated. Its functions were to cause the printing arrangement to be affected at the right moment by the positions taken and preserved on a special ratchet wheel by a catch whose fall is actuated by an electromagnet which receives the line current, and which, as it were, registers the *moment* of arrival of that current. The type-wheel moving more slowly than the "distributor" is by means of the "compensator" enabled to print the appropriate signs during the time oçcupied in one revolution of the "distributor." In his model of 1887 the inventor arranged the 28 contacts of the sectors in concentric crowns instead of placing them successively upon one crown. For a quadruple transmission each contact occupied an angle of 4/112 of the periphery, and the angular space between the symmetric points of the contacts of neighbouring crowns was 1/112, the result being the same as if the contacts followed each other on the periphery and measured 1/112th.

With a view to increasing the speed of the apparatus the inventor has in his latest form abandoned the "compensator" and substituted a new arrangement which he calls a "collector," and he has modified his "distributor" by providing five divisions per sector, two for divisions of the letters of the alphabet in series and three for the letters in the series. Two brief impulses form a combination, one indicating the series, and the other for selecting the letter in that series. This result has been obtained by utilising on the one part currents of opposite signs and, on the other, a set of electromagnetic receivers designed to open and close the circuits of the "collector" containing as many divisions as a type-wheel. The "collector" is composed of two concentric crowns, the outer of which has 28 divisions corresponding to those of the Hughes type-wheel, and the other is divided into 5 parts corresponding to the 5 series of the manipulating board. Each part embraces a series and faces 6 of the divisions of the first crown, except the last part which

faces 4 only. Over the two crowns travel two metallic brushes connected together. These unite successively the series to the divisions for printing the characters signalled by the armatures of the electromagnets. They are fixed on a carrier forming part of the type-wheel. E. O. W.

2122. *Long-distance Telephony over Non-Uniform Cables.* **M. I. Pupin.** (Amer. Inst. Elect. Engin., Trans. 17. pp. 245–307, April, 1900. Part II. is a reprint from Amer. Math. Soc., Trans. I.)—This paper describes and discusses a method of constructing cables and long-distance air-lines for telephony and telegraphy in which capacities and inductances are inserted at equal distances. When these distances are small in comparison with the lengths of the electric waves in use the periodically loaded line is said to behave like a uniform line, but with less distortion than when without the loads. E. H. B.

2123. *Telephone Construction.* **J. E. Stewart.** (West. Electn. 26. p. 407, June 23, 1900. Paper read before the National Telephone Association at Cleveland, June 13, 1900.)—The author describes American practice. For overhead lines he recommends 35 to 40-foot poles with 8-inch top and 42 to 43 inches circumference at 6 feet from the butt, carrying 4 to 10 insulator arms. Second growth chestnut or white cedar is best, and should be cut in winter-time when sap is down. The poles should be spaced 40 to the mile on the straight and 45 to 50 on curves, and buried 5½ feet with additional 6 inches for every 5 feet of length. Cross arms for 10 insulators 3¼ by 4¼ inches section and 10 feet long of best heart pine or fir. Bolted through arm and pole with ⅝-inch bolt, and braced with a 1¼ by ¼ by 28 wide galvanised iron. Hard-drawn copper wire No. 10 B. and S. is the best for long distances, and of course metallic circuits in all cases; and No. 14 to 18 for subscribers' circuits; a No. 14 twisted pair, rubber-covered, and braided through trees, &c., to the subscriber's place. For underground purposes, wooden or terra-cotta ducts are used. The former is creosoted under 80 lbs. pressure, and is then indestructible. A creosoted board of width equal to the duct is laid as floor; the ducts are laid with wooden joints, and another board put on top. This should be 2 feet or more below the street surface. Under terra-cotta ducts, 4 inches of concrete are first laid. When multiple, two dowel pins, ⅝ by 4 inches, should be used for each section of duct. A strip of hurlap, 6 inches wide and well soaked in asphaltum varnish, should be wrapped round the joint. The latter should then be grouted. The sides round the ducts should be filled with 3 inches of concrete and also on top. Over all a creosoted plank should be laid for the entire width to protect against accidental excavations. Ample manholes are required, 450 or 400 feet apart, with 9 to 13-inch walls, and 6 feet in depth, frame and covers resting upon the walls, covers being filled with asphaltum. All conduits or ducts should be rodded and pilot wires drawn in before completion is accepted. E. O. W.

2124. *Mildé's Telephones.* **L. Montillot.** (Électricien, 20. pp. 22–27, July 14, 1900.)—A description of wall and portable telephones, the particular features by which they differ from familiar types being the transmitters. For a wall instrument one type consists of two cylinders of carbon fixed into the two sides of a round, flat, metallic box, and separated from the metal by paper washers. The box is filled, loosely, with granules of coke. One cylinder is fixed, together with a cork washer, against the deal panel spoken to. The ends of the carbon rods which impinge upon the granules are lightly striated. The usual wires from the primary coil and battery are

attached to the rods. Another form of microphone for portable purposes is designed by Steiner. Two corrugated metallic shells form the box. The upper one is corrugated horizontally, and has a cylindro-conical and striated carbon going through its centre. The lower one is conically corrugated and receives a carbon with a hollow or dished end, also striated. The space between the shells and carbons is filled with a special carbon powder, semi-conductive. The carbons are insulated from the metallic shells, and are connected as usual to the primary and battery. This microphone will function in any position, and can be used with an E.M.F. of even 8 volts without hissing. Another form of transmitter for a desk telephone is that of Kotyra. The carbon cylinders or rods are of the forms just described, but are surrounded by a band of cloth, which confines the space necessary for the granules of graphite, and makes an elastic box. This arrangement is inserted in a metallic tube, which is helically embossed and forms another elastic case. One extremity of the tube is closed by a metallic, the other by an ebonite plug. This latter is attached to the sounding-board of deal, with a cork washer intervening; one wire is fastened to the metal tube, the other penetrates the ebonite to the carbon inside. E. O. W.

2125. *Telephone-coherer.* **T. Tommasina.** (Elettricità, Milan, 19. pp. 370–374, June 16, 1900.)—The telephone-coherer is similar to an ordinary Bell telephone, except that the core is iron instead of steel. The diaphragm carries a small circular chamber of insulating material containing filings, and acting as the coherer. Two wires communicating with the filings are joined as usual to the receiving mast, a battery, a relay, and earth. The telephone coil is in the circuit closed by the relay. This arrangement gives a combined coherer and decoherer, for decoherence is produced by the movement of the diaphragm when the telephone circuit is closed by the relay, and also, when nickel and silver filings are employed, by magnetisation. When it is not required to print the signals they can be read by the sound emitted by the telephone diaphragm.

The "Telephone-auto-decoherer," or "Radio Telephone," has been designed by the author as a very simple and portable apparatus, giving sound signals only, but requiring no relay, and only one battery cell. The telephone coil is in series with one of the author's carbon self-decoherers, which is placed in a cavity in the telephone case. The telephone terminals are then connected in parallel with a battery and the receiving mast and earth. G. H. B.

REFERENCE.

2126. *Telephone Statistics.* (Journ. Télégraph. 24. pp. 150–160, July, 1900.)—A tabular statement, giving financial, technical, and general particulars about the telephone systems in the different countries of the world.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

NOVEMBER 1900.

GENERAL PHYSICS.

2127. *Gravity and Temperature below the Earth's Surface.* **R. v. Sterneck.** (Akad. Wiss. Wien, Sitzb. 108. pp. 697–766, 1899.)—Observations of the acceleration due to gravity and of the temperature have been made in three mines in Bohemia, and in the well-known quicksilver-mine at Idria in Craniola [see Abstract No. 1986 (1900)]. The copious results hardly admit of generalisation, but they seem to indicate that there is a tendency for an increase in temperature downwards to be associated with an increase in gravity, and, the larger the increase of the one, the larger appears to be the increase of the other. A. G.

2128. *Strength of Ductile Materials under Combined Stress.* **J. J. Guest.** (Phil. Mag. 50. pp. 69–182, July, 1900. Paper read before the Physical Society of London.)—The author discusses the present state of knowledge regarding the laws of strength, discusses the criterion of strength, choosing the yield-point rather than the ultimate stress in tensile tests, and the nature of the elastic limit in reference to the yield-point. The elastic limit effect may be mainly due to local yielding; the author has therefore assumed that Hooke's law held up to that point.

Previous experiments upon the yield-point under combined stress have usually been on torsion; those of Kelvin on piano wire show that simultaneous tension lowered the yield-point in torsion. Torsion presents a case of combined stresses, the two principal stresses being equal in amount but opposite in sign, while the third is zero. A large number of tests have been made on round bars, but the essentials of the phenomena are masked by the variation of strain from the axis outwards; to avoid this, the author conducted his experiments upon thin tubes, the thickness of the walls being from $\frac{1}{10}$ to $\frac{1}{15}$ the radius. Further, the tubular specimens could be easily subjected to internal fluid pressure simultaneously with tension or torsion.

The method of experimenting was to subject the tubes to torque and tension combined, to tension only, to tension and internal pressure combined, to torsion and internal pressure combined, and to internal pressure only; and to take measurements of the principal strains. The range of the two principal stresses thus covered was from $-p$ and $+p$ to $+p$ and $+p$, the third principal stress being small or zero.

The specimens were of tubes (steel, copper, and brass) soldered on to holders which served to apply the tension loads and the torques, and to introduce fluid under pressure to the interior of the tubes. The size of tube was 1¼ inches diameter with walls from 0·025 inch to 0·036 inch thick. The tension loads were applied by a 10-ton Wickstead machine, and special apparatus, which is fully described, was designed for the application of the torque and internal pressure. A new type of pressure gauge was made, consisting of a steel tube of oval section twisted so that the tube had a straight axis, but the extremities of the major axes of the sections perpendicular to the tube axis lay on a pair of helices of about 45° to 60° angle. A new extensometer on the lever and mirror system was made, the extensions being read by telescope and scale as in the Unwin extensometer. A new twist measuring apparatus consisting of two mirrors and a scale placed horizontally and read by light reflected at each of the mirrors was devised. The normals to the mirrors were inclined about 45° to the axis of the specimen. If the normals to the mirror are perpendicular to the specimen, the reflected optical axis is turned through twice the angle the specimen twists through. By allowing a ray of light after reflection from the two mirrors to fall upon a scale, the device forms a cheap and convenient form of transmission dynamometer, since the reading can be taken when the light is intermittent. A diametral extensometer was designed, and is described in the paper.

The method of making the tests is fully described, as well as the methods of determining the sectional area and thickness of the tubes. The results of the experiments show that the material and shape of the tubes are such as to give reliable results. Throughout a series of tests on any tube the yield-point stress has nearly the same value in tests of the same type. The maximum principal stress varies very largely, its least value being found in the pure torsion tests, while in the tests by tension and internal pressure its value is practically constant. The maximum principal strain varies throughout the experiments, it is greatest in the simple tension experiments, and least either in the torsion tests or when the axial and circumferential tensions are equal. The variations of the maximum strain are considerable for all the materials experimented on. The maximum shearing stress, and the maximum shearing strain or slide are comparatively constant, although the amount is highest in the case of pure torsion. The principal conclusion drawn from these experiments, as applicable to practice, is that the conditions for initial yield of a uniform ductile material is the existence of a specific shearing stress, and that the intermediate principal stress is without effect.

The paper is accompanied by numerous illustrations of the apparatus employed, and tables and diagrams giving the results of the tests. A. S.

2129. *New System of Units.* **F. J. Rogers.** (Phys. Rev. 11. pp. 115–116, Aug., 1900.)—To avoid the large numbers which the c.g.s. system of units introduces into practical work, the author proposes the M.K.S. or meter-kilogramme second system. The only new unit introduced by adopting this system is a "Large Dyne" $= 1 \text{ kg.} \frac{\text{m}}{\text{sec}^2}$. The units of power and work become 1 watt and 1 joule respectively. G. H. B.

2130. *Balances for Automatic Weight Exchange.* **H. Stadthagen.** (Zeitschr. Instrumentenk. 20. pp. 206–207, July, 1900.)—In balances of this type, the weight is supported, not by a tray, but by a cross or a Y. When, however, a combination of $200 + 200 + 100$ g. is to be compared with one

weight of 500 g., some kind of tray has to be resorted to. To avoid this necessity, Stückrath in Friedenau has constructed a kind of grate support, open in front and at the sides, on which combinations can be placed. The balance has been supplied for the German standardising department, along with weights up to 25 kg., and is made partly of the aluminium alloy partinium. There is no detailed description or diagram. H. B.

2131. *Physical Properties of Cobalt and Nickel.* **E. van Aubel.** (Archives des Sciences, 10. pp. 144–148, Aug., 1900.)—Two properties of these metals in the pure state have been accurately determined, viz., the coefficient of expansion and the specific heat.

Coefficients of Expansion.

Pure nickel	$10^{-8}(1248 + 0{\cdot}74t)$
„ cobalt	$10^{-8}(1208 + 0{\cdot}64t)$

Specific Heat.

	Nickel.	Cobalt.
Between 100° and 15°	0·10842	0·10303
„ 15° and − 78·4	0·0975	0·0939
„ 15° and − 182·4	0·0838	0·0822

The difference between the specific heats therefore increases as the temperature rises.

According to the results of Pionchon the specific heat of nickel is at first a little greater than that of cobalt, and becomes very much less at higher temperatures.

The electrical resistance is very different for the two metals:—

Silver	100
Cobalt	17·22
Nickel	13·11

The author points out that sodium and magnesium, aluminium and silicon, sulphur and phosphorus, which taken two and two present but small differences in atomic weight, are widely different in their coefficients of expansion and fusion-points. W. C. O.

2132. *Automatic Mercury Air-Pump.* **F. Neesen.** (Zeitschr. Instrumentenk. 20. pp. 205–206, July, 1900.)—The author describes improvements in his air-pumps, which were referred to in Abstract No. 1461 (1899). The capillary connection between the horizontal tubular recipient and the barometer tube contains several bends and bulbs, and the auxiliary starting pump branches off from it. From the other end of the recipient start the charging and the return pipes, connected below with a second cylindrical glass vessel which communicates by rubber tubing with a pair of small bulbs, suspended from the three-way cock; the weight of these bulbs is partly counterbalanced. When the auxiliary pump acts, the mercury will rush from the bulbs, so that the counterpoise will throw the cock over, breaking the communication between the lower cylindrical vessel and the outer air; the bulbs will then be refilled with mercury and pull the cock back again. The pump works quietly, and the improvements permit of a rapid flow of the mercury through the capillary. H. B.

2133. *Annual Report of Physikalisch-Technische Reichsanstalt.* (Zeitschr. Instrumentenk. 20. pp. 140–150, May, and 172–186, June, 1900. Extract from the report on the work of the Reichsanstalt, presented in March, 1900.) —These papers contain an abstract of the work done in the Reichsanstalt from Feb., 1899, to Feb., 1900, and, extending as this abstract does to twenty-four pages of the Zeitschrift, if again abstracted, the final abstract can only form an index to the valuable work contained in the original report.

The number of persons engaged in the Institute was 87. The work is divided into two classes according to the departments in which it is done. One department deals only with Research and the other with Standardising. Each department is again divided up into laboratories for heat, light, electricity, &c. In the Research Department the following subjects have been experimentally treated during the year :—

Heat.—Density of water. Vapour pressure of water at low temperatures. Vapour pressures of water near the temperature 50° C. Density of water vapour. Thermometers. Air-thermometers for high temperatures. Thermometers for very low temperatures. Electric heating. Ratio of heat conductivity to electric conductivity of metals. Fizeau-Abbe's Dilatometer. Passage of heat through hot-plates.

Electric.—Standard resistances. Capacity of condensers and its constancy. Standard cells. Conductivity of electrolytes.

Optics.—Light emission of a black body and temperature. Proof of Stefan's law between 90° and 1,700° abs. Unit of illumination. Absolute measurement of radiation. Distribution of energy in the spectrum of black bodies. Distribution of energy in the spectrum of polished platinum and other bodies, also their reflecting powers.

The work done in the Standardising department is divided into six classes : —Mechanical, Electrical, Heat and Pressure, Optics, Chemistry and Workshop, and as the fourteen pages in the papers which are devoted to the work of this department do not contain much more than a list of the different headings of the year's work and the numbers of the different kinds of instruments which have been tested, it is impossible to reproduce them here.

J. B. H.

2134. *Stereoscopic Lissajous Curves.* **M. Dechevrens.** (Comptes Rendus, 131. pp. 408–410, Aug. 13, 1900.)—The author describes a curious property of his "campylograph" [see Abstract 1767 (1900)], which traces Lissajous figures on a revolving plate. When two consecutive figures are traced, and the second has a slightly different phase-relation from the first, the two figures have stereoscopic properties. Viewed in a stereoscope, the curves appear to consist of a continuous wire mounting upwards, and inscribed in a cylinder or sphere. The author explains this effect by showing that there is an apparent difference in the axis of revolution in the two figures. E. E. F.

2135. *Fractionating Rain-Gauge.* **J. Joly.** (Roy. Dublin Soc., Proc. 9. pp. 283–288, March 8, 1900.)—In order to determine the amount of sodium chloride carried by the atmosphere, which decreases as the air travels from the sea inland, the author has constructed a rain-gauge which fills separate bottles with definite quantities, *e.g.*, 0·1 inch, of rain. From the funnel the rain passes through a narrow tube, and then through a wider one, into the reservoir, into which dip the shorter legs of a number of siphons, fixed in different bottles. The bends of the various siphons are at different levels, so

that they function one after the other. A second siphon may be placed in the bottle so that successive tenth parts can be withdrawn. In order to ensure cessation of the action of the siphon as soon as the corresponding bottle is full, the short limb consists of a rubber tube, surrounded by a glass tube, and ending in a wide-mouthed funnel, resembling an inverted bell. When the water in the reservoir sinks below the level of this bell-shaped siphon limb, a mixture of air and water will be sucked up, and a premature flow might ensue. The bell-mouth being wide and elastically suspended by a piece of rubber tubing, the rubber will be stretched as long as the bell is still full of water, and contract as soon as the mouth is finally uncovered. H. B.

2136. *Areometer Barometer.* **K. T. Fischer.** (Phys. Zeitschr. 1. pp. 394–396, June 16, 1900.)—This barometer is designed for balloon observations, as ordinary barometers indicate too low during the rise and too high during the fall of the balloon. The instrument may be described as a Cartesian diver. The float consists of stem, cylinder partly filled with water, the free space being taken up by air, and bulb charged with mercury; it is made of glass and swims in a brass cylinder containing distilled water. This cylinder is surrounded by a shell of ice, placed within a chamber packed with ice. The temperature being thus kept constant, the position of the float will depend upon the volume of the air intercepted in the float, which varies with the atmospheric pressure acting on the water in the brass cylinder. For exact determinations the stem is sealed off, and the cylindrical part weighed together with the bulb. Experiments, made in lifts and balloons, show that the instrument is not affected by upward or downward movement, and laboratory comparisons with an aneroid mark the superiority of the new barometer which gives identical curves for increasing and decreasing pressures. H. B.

2137. *Lake Levels and Wind Phenomena.* **A. J. Henry.** (Monthly Weather Rev. 28. pp. 203–205, May, 1900; reprinted from the Lake Chart for July, 1900.)—This paper deals with the changes in the level of Lake Erie, as observed at Amherstburg, Ontario, and Buffalo Harbour, the two stations being situated respectively at the western and eastern extremities of the lake. The curves reproduced concern the periods March 4–10, and March 22–29, 1900. During the first period, a storm moved from the Mississippi Valley in a northerly direction across the Lake region. The water rose at Amherstburg, fell, and rose again, and the converse fluctuations were observed at Buffalo. These fluctuations are due to the north-easterly wind in front of the advancing storm, and the shifting or backing of the wind to south-west; as the storm centre advanced, a second oscillation followed in the opposite sense. The amplitude of the oscillation may reach the extreme value of 7 feet. In the second case, a storm moved right east across the lake with considerably smaller velocity; the wind backed to north-west, and the oscillation was transverse rather than longitudinal. The synchronism of high water at Amherstburg and low water at Buffalo was almost perfect. The period of a complete oscillation was from twelve to sixteen hours; assuming the lake to have a mean depth of 50 feet, a period of seventeen hours would be computed. The oscillations are stationary rather than progressive, the whole lake oscillating about a nodal line; dangerous currents are not engendered in mid-lake. The oscillations do not appear to occur with all storms, and a given wind velocity does not produce a corresponding change in the water level, but forecasts could probably be made of the more pronounced oscillations. H. B.

2138. *Van der Waals' Thermodynamic Theory of Capillarity.* **G. Bakker.** (Zeitschr. Phys. Chem. 34. pp. 168–178, July 17, 1900.)—Van der Waals, in the last chapter of his work, finds for the energy per unit of mass at a point of a capillary layer between two parallel planes, with continuous variation of density, the expression—

$$\epsilon = C - a\rho - \frac{c_2}{1.2}\frac{d^2\rho}{dh^2} - \frac{c_4}{1.2.3.4}\frac{d^4\rho}{dh^4} - \&c.$$

Here a, c_2, c_4, &c., are integrals depending on the law of force only. With the exception of his last chapter, van der Waals in all his work uses the first three terms of this series alone as a sufficient approximation. In the last chapter he himself raises the question whether the remaining terms are really negligible.

Bakker, in the present paper, shows that on van der Waals' assumption of the potential function $\frac{1}{r}\epsilon^{-\frac{r}{\lambda}}$, the terms after the third are not negligible. He gives also a different method of obtaining the general differential equation of van der Waals, and concludes that van der Waals' last chapter must be separated from the rest of his work; as, if it be right, the calculation of density and capillary energy in the rest of the work require modification.

In paragraph (2) the author discusses the thermal pressure at a point in the transition layer, and concludes that it has the same value as it would have if the fluid were homogeneous and of the same density as at the point considered. He then, in (3), determines the differential equation which V, the potential function, satisfies. In paragraph (4) he discusses the capillary energy, and criticises some statements of van der Waals [see also Abstract No. 1320 (1899).] S. H. B.

2139. *Theory of Capillarity, II.* **G. Bakker.** (Journ. de Physique, 9. pp. 394–404, July, 1900.)—The writer assumes a fluid bounded by an infinite plane, taken for that of yz, and the forces excited on a particle near the surface to be derived from a potential ψ, which diminishes very rapidly as x increases from zero, so that we may write $\psi = A\epsilon^{-qx}$.

He proves several mathematical theorems, using a form of potential like that of Carl Neumann, namely, $\phi(r) = \frac{A\epsilon^{-qr} + B\epsilon^{qr}}{r}$; but if the force function diminishes as r increases, A must be negative and B zero, so that the form finally adopted is $\phi(r) = -f\epsilon^{-qr}/r$.

The author then points out that the analogy of the pairs of equations—

$$\left.\begin{aligned}\nabla^2\psi &= 4\pi f\rho \\ \psi &= -\frac{f}{r}\end{aligned}\right\}$$

and—

$$\left.\begin{aligned}\nabla^2\psi &= q^2\psi + 4\pi f\rho \\ \psi &= -f\frac{\epsilon^{-qr}}{r}\end{aligned}\right\}$$

leads him to seek, in the theory of capillarity, equations analogous to those discovered by Maxwell for energy and tension in the theory of electrostatics, and with this discussion the latter part of the memoir is occupied [see also Abstract No. 31 (1900).] S. H. B.

2140. *Motion Produced in an Infinite Elastic Solid by the Motion through the Space occupied by it of a Body acting on it only by Attraction or Repulsion.*

Kelvin. (Phil. Mag. 50. pp. 181–198, Aug., 1900. Paper read before the Royal Society of Edinburgh, July, 1900.)—The author supposes a spherical portion of space occupied by matter which attracts or repels every portion of the infinite elastic solid representing ether with a force varying as the inverse square of the distance. The force is thus of the form $\frac{a}{r^2}$, where r is the distance and a denotes the intensity of the attractive quality for ether of the matter considered, and is negative when the force is repulsive. The system of matter within the spherical space is called an atom. It is assumed that integrating throughout the atom, $\iint r^2 a dr = 0$. The author further assumes the distribution of positive and negative density within the atom, and the law of compressibility of the ether, to be such that the average density of the ether within the atom is equal to the undisturbed density of the ether outside. On these assumptions he works out the mathematics of his subject with the aid of diagrams. Two problems are solved, viz.: (1) to find the orbit of a particle of ether as disturbed by the moving atom; (2) to find the path traced through the atom, supposed fixed, while the surrounding ether is supposed to move uniformly in parallel lines. Also the effect on the refractive index is considered, due to assumed densities of ether at points within the atom.

In conclusion the author refers to the Michelson-Morley experiment (Phil. Mag., Dec., 1887, discussed also by Larmor, Ether and Matter, p. 46) as creating a difficulty. He can find no flaw either in the idea or the execution of this experiment, but thinks that a suggestion due to Fitzgerald that the stone slab used in that experiment has, by virtue of its translation through ether, its linear dimensions shortened by a minute portion, affords a means of escape from the difficulty. S. H. B.

2141. *The Duties of Ether for Electricity and Magnetism.* **Kelvin.** (Phil. Mag. 50. pp. 305–307, Sept., 1900.)—This is a short supplement to the author's paper in the Phil. Mag., Aug., 1900 [see preceding Abstract]. It is the substance of a statement made by the writer to the Congrès International de Physique in Paris on August 8. The writer seeks to explain how, if a positive electron condenses ether in its neighbourhood by attraction, and a negative electron rarifies it by repulsion, it comes about that the two attract each other according to the Newtonian law. He then goes on to explain how the ether, being, as he shows, "freed from the impossible task of transmitting both electrostatic and magnetic force," may be competent to perform the simpler duty of transmitting magnetic force alone. S. H. B.

2142. *Constitution of the Atmosphere at Various Heights.* **G. Hinrichs.** (Comptes Rendus, 131. pp. 442–443, Aug. 20, 1900.)—Working from the formula connecting the pressure and density of a gas, the author calculates the percentage composition of the atmosphere at intervals of 10,000 metres [6·2 miles], and gives a table showing the order in which the several constituents are left behind. At an altitude of over 60 miles the atmosphere will consist mainly (95 per cent.) of hydrogen, and the author suggests that this may be the source of the occluded hydrogen usually found in meteoric fragments. C. P. B.

2143. *The Classes of Progressive Long Waves.* **R. F. Gwyther.** (Phil. Mag. 50. pp. 213–216, Aug., and pp. 308–312, Sept., 1900.)—The author adopts

Rayleigh's method, but, instead of obtaining a differential equation approximately related to the free surface, he eliminates the vertical co-ordinate from the stream function and the condition for uniformity of pressure along the free surface. Approximate solutions of the resulting functional equation lead to three classes of long waves. The first class is of small amplitude. The second class appears to be connected with the stationary cnoidal wave of Korteweg and de Vries; a particular case is the low solitary wave of Scott Russell, for which the method determines the potential and stream functions assumed by McCowan in his investigation of the properties of that wave. The third class is the most general case of elliptic function waves.

In order to test the method of approximation adopted in the first of these papers the author pursues the investigation to a higher order of approximation, particularly in the case of the solitary wave. The approximate identity of a formula arrived at, and one demonstrated by Stokes for the outskirts of a solitary wave, forms the condition for the existence of a solitary wave of a certain amplitude. As under proper restrictions we know that such a wave is capable of propagation, the comparison of the relations under these circumstances is the proper test of the author's mode of treatment of the problem. The expressions are found to be in approximate agreement.

W. E. T.

2144. *Actinometric Observations during Total Solar Eclipse.* **J. Violle.** (Comptes Rendus, 130. pp. 1658–1661, June 18, 1900.)—During the total eclipse of May 28, 1900, the author provided for actinometric observations in two series, one by means of an apparatus attached to a captive balloon, the other on the summit of the Pic du Midi (altitude 2,860 m.). The results are plotted as curves, and show a close agreement with theoretical calculations computed from the varying amounts of the solar disc obscured during the progress of the eclipse. C. P. B.

2145. *Physical Meaning of Star-Magnitude.* **R. de Kövesligethy.** (Astrophys. Journ. 11. pp. 350–356, June, 1900.)—This paper is an attempt to connect the varying degrees of stellar magnitude with the physical condition of the star rather than regard it as a measure of the relative distance of bodies of intrinsically equal brightness. The author obtains an integral formula for the spectrum, and specialises it for the different types of stars, determining the constants by actual photometric measures of standard type stars. On such supposition a change in magnitude may be given in terms of, say, change in temperature. For example, if a *white* star changes in magnitude by *one* order it may be said to be the same as if its superficial temperature fell from 6,400° to 5,274°, or on another assumption to 5,230°.

The theory may be usefully extended to the study of new stars, &c., as showing the probable degree of increase of temperature with luminosity. Nova T Corona increased by three magnitudes in about $2\frac{1}{4}$ hours, which would correspond to an increase of about 0·5° C. per second. C. P. B.

REFERENCES.

2146. *Variation of Atmospheric Pressure and Moon's Declination.* **R. Börnstein.** (Phys. Zeitschr. 1. pp. 446–448, July 14, 1900.)—This is a continuation of the paper referred to in Abstract No. 1246 (1900). Curves are given showing the mean variation of atmospheric pressure during the lunar month at Berlin for various times during the period 1884–1898. C. P. B.

2147. *Recent Studies in Gravitation.* **J. H. Poynting.** (Nature, 62. pp. 403–408, Aug. 23, 1900. Paper read before the Royal Institution, Feb. 23, 1900.)

2148. *Stellar Spectra.* **Cornu.** (Bureau des Longitudes, Ann. pp. 299–306, 1900.)—A brief review of the various classes recognised in the study of stellar spectroscopy, with a map illustrating the distinctive features of each group. Reference is made to the determination of motions in the line of sight. C. P. B.

2149. *Orientation of Field of Siderostat and Cœlostat.* **A. Fowler.** (Nature, 62. pp. 428–430, Aug. 30, 1900.)—This is a discussion of a paper by Cornu [see Abstract No. 1032 (1900)], with additional formulæ to extend the problem to the cœlostat ; an instrument consisting of a plane mirror having a single motion, parallel to the diurnal motion of the earth, but at only half the rate, making one revolution in forty-eight hours. A photograph is given of the instrument in position for observatory use. C. P. B.

2150. *Discussion of Nebular Hypothesis.* **T. C. Chamberlin** and **F. R. Moulton.** (Science, 12. pp. 201–208, Aug. 10, 1900.)—This paper is condensed from several others given by the authors at various times, discussing the discrepancies between the conclusions of the Laplacian theory and those indicated by modern mathematical analysis of the conditions governing gaseous masses. [See also Abstracts Nos. 805 and 997 (1900).] C. P. B.

2151. *Total Solar Eclipse, May* 28, 1900. (Frank. Inst., Journ. 150. pp. 133–151, August, 1900.)—Observation by Watts and others showing probable atmospheric origin of the shadow bands, determination of the wave-length of the corona line (λ 5304), and estimates of the varying luminosity during eclipse form the main substance of the paper. C. P. B.

LIGHT.

2152. *Sources of Monochromatic Light.* **C. Fabry** and **A. Pérot.** (Journ. de Physique, 9. pp. 369–382, July, 1900.)—This paper consists of a useful series of descriptions of the various methods used by the authors for obtaining monochromatic lights of varying degrees of purity in their researches on interference measurements. The most useful cases were: (1) simplification of white light by analysis of spectrum; (2) emission spectrum of a gas; (3) flames; (4) gases electrically excited by various sources of power; (5) electric spark; (6) electric arc in air; (7) electric arc in vacuo. The final choice was fixed on a mercury arc in vacuo, using the green line chiefly, the other radiations being suppressed by interpolated solutions of quinine, eosine, &c. C. P. B.

2153. *Photometry of Arc Lamps.* **F. W. Carter.** (Elect. Rev. 47. pp. 44–45, July 13; 120–121, July 20; 128–129, July 27, and pp. 197–198, Aug. 3, 1900.)—This paper gives details, illustrated by drawings, of a plant for testing arc lamps. A modified form of photometer, termed a "distinctness" photometer, is described in which the observation face of, *e.g.*, the two blocks of paraffin wax in the Joly photometer, is covered with a plate marked with a graduated mesh, and instead of comparing the illuminations the observer seeks the level at which the mesh becomes so fine as to be indistinct, and moves the photometer until this level is the same on both sides of the centre line. The mesh is preferably observed through a telescope whose aperture can be reduced by means of an adjustable diaphragm in order to vary the apparent brightness of the mesh. An apparatus is also described for obtaining the polar curve by comparing the candle-power in one direction, *e.g.*, the horizontal, with those at other angles, this being effected by reflecting the light at the two angles in opposite directions along the photometer bench by means of mirrors. C. K. F.

2154. *Photometer for Mean Spherical Candle-Power.* **R. Ulbricht.** (Elektrotechn. Zeitschr. 21. pp. 595–597, July 19, 1900.)—The principle on which the photometer is based is that in a spherical globe with diffusing surface containing a source of light the illumination due to the diffuse reflected light is uniform throughout the whole surface of the globe, however variable be the intensity of the light in different directions. The mean direct illumination then bears to the uniform illumination, due to the diffused and reflected light, a constant ratio which depends only on the nature of the diffusing surface of the globe. For a diffusing surface formed on glass by a layer of chalk held in a suitable medium, this ratio is about four to one.

The photometer is constructed as follows: a globe of milk glass is covered inside with a layer of chalk and outside with an opaque covering, leaving transparent only a small circular area, the illumination of which is measured by an ordinary photometer. The rays from the lamp in the globe are prevented from falling directly on this area by an opaque white screen with diffusing surface, and only large enough to shade the transparent area. The illumination of the area is then due only to reflected light, and its candle-*power* as measured by the photometer is equal to the mean spherical

candle-power of the lamp within the globe multiplied by a factor which is constant for any one arrangement of globe and screen.

To test how far the truth of the principle on which the photometer is based is borne out in practice the author enclosed in the globe a half-obscured incandescent lamp, and measured its candle-power when giving light in different directions relative to the transparent area on the globe. The results show that the mean spherical candle-power can be determined by one measurement on this photometer with an accuracy well within the limits of error of ordinary photometry. G. H. B.

2155. *Electro-photography.* **F. E. Nipher.** (Elect. Rev. 47. pp. 207–208, Aug. 10, 1900. From a paper in the Transactions of the Academy of Science of St. Louis, vol. x. No. 6.)—Photographic plates are prepared by exposing them to the light of an ordinary room for from one to nine days. The plate is laid on a plate of glass covering a plate of metal connected to one electrode of an influence machine. The coin or medal is connected to the other electrode, preferably through a spark-gap. The exposure is from four to ten minutes. A much longer exposure reverses the picture and gives a positive. The exposure should be in a darkened room, as light counteracts the electrical effect. Development must be carried out in a moderate light, such as that of a single incandescent lamp, and detail can be brought out by carefully varying the distance from the lamp during development. Coins show the lettering and device, and also a halo at some distance from the edge. Ordinary objects may be photographed as positives by exposing the plates to Röntgen rays for several hours and then over-exposing them thirty or forty times. Development can then be carried out in daylight, and very rich effects obtained. The author also describes a method of producing a globe discharge by attaching a ball provided with a needle-point to one of the terminals of the influence machine and bringing the needle-point into contact with the sensitive plate.

E. E. F.

2156. *Measurement of Photographic Intensities.* **E. C. Pickering.** (Astrophys. Journ. 11. pp. 416–420, June, 1900; from the Harvard College Observatory Circular, No. 50.)—This is a review of the various methods adopted at the Harvard College Observatory from time to time for the measurement and comparison of photographic light intensities. Since 1887 all the photographs obtained at the Observatory have had the image of a standard light scale impressed upon them for subsequent comparison. The methods now in use have been developed by E. S. King. All sources of light, that of the sun, moon, sky, milky way, aurora, and stars, are in this way to be referred to one standard, given by the meridian photometer, with which the star Polaris has a magnitude of 2·15. The artificial standard for practical convenience is that furnished by an Argand burner behind a small aperture, but this is compared with Polaris every month, when a series of tests are made on an 8 × 10-inch plate, which is then cut up and the various parts stored for future inspection. These monthly comparisons, in addition, furnish a valuable check on the constancy of the plate and the developer used, and will, moreover, as the several parts of the divided plate are developed at different periods, furnish data concerning any change in the impressed image dependent on the interval between exposure and development. Spectroscopic photometry is also adopted to record the photographic intensity in terms of light of a particular wave-length.

In the same paper is also included a description of the method evolved by

W. H. Pickering for reducing the standard of comparison to the actual radiation received from a certain star shining directly on to the sensitive plate. This unit, however, being so small, secondary and tertiary standards have been made from it by using lenses of known aperture and focal length. Thus, with a simple plano-convex lens of 8·2 cm. aperture, the image of *a* Ursæ Minoris was received on a piece of ground glass placed 3 cm. from the photographic plate. The "*sensitive tint*" was produced after twenty minutes' exposure, and the intensity of the light was calculated to be *thirty* times greater than the direct radiation from the star. For lights of greater intensity this secondary standard is still too small, and then recourse is had to the Argand burner constant. C. P. B.

2157. *Sensitometry of Photographic Plates.* **J. M. Eder.** (Akad. Wiss. Wien, Sitzb. 108. pp. 1407–1498, 1899.)—The author adopts Scheiner's sensitometer, which consists of a disc rotating in front of a dark slide which contains a long narrow plate. An opening is cut in the disc, increasing in width by steps from the periphery to the centre. The plate is thus given exposures increasing in duration by steps from one end to the other, the exposure ratio of successive steps being 1 : 1·27. The source of light was a Scheiner benzene standard of candle-power equal to 0·076 that of the Hefner amylacetate lamp.

For comparisons of the density of silver deposit on plates, a series of plates exposed in the Scheiner sensitometer were calibrated in a Weber photometer, the ratio of the incident to the transmitted light being determined for each gradation. These plates were used as standards to measure the density on any plate in Hartmann's mikrophotometer, in which a single light illuminates the two plates from behind, and two objectives bring the images of the plates together into the field of one eyepiece.

As a measure of sensitiveness of a plate the author proposes the quantity of light necessary to produce the faintest visible image on development. This is claimed to be a more determinate quantity than that adopted by the Paris Congress of 1889, namely, the quantity of light necessary to produce a standard degree of blackening. The fog of a plate, *i.e.*, the blackening produced by development without exposure to light, is a very variable quantity, and vitiates the method of the Paris Congress.

The author exposes the plate in Scheiner's sensitometer behind a metal screen stamped out with the numbers corresponding to the different durations of exposure. The faintest number visible on development by iron oxalate after a definite exposure is taken as a measure of the sensitiveness.

The author confirms Schwarzschild's results [Abstract No. 815 (1900)] that the blackening of a plate is not proportional to the quantity of incident light, but depends also on the intensity of the light, and on whether the exposure is intermittent or continuous. He shows how these variations from Bunsen's reciprocity law may be corrected in determining the sensitiveness of a plate.

A large number of "blackening curves" are given for different plates and different developers, and times of development; the ordinates represent the blackening or the log. of the ratio of incident to transmitted light, and the abscissæ the amount of light incident during exposure. In the lower portion of the curve, corresponding to under-exposure, the blackening is nearly proportional to the quantity of incident light; in the succeeding steeper portion, corresponding to correct exposure, the increase of blackening is nearly proportional to the increase of the log. of the quantity of light; in the last portion the inclination of the curve becomes similar to that of the first

portion, and corresponds to over-exposure. Longer development produces greater blackening and steeper curves, corresponding to greater contrast in the plate. The addition of potassium bromide has a marked influence in diminishing fog in the case of iron oxalate developer. Hydroquinone gives a great deal of fog, adurol less, though more than iron oxalate.

The influence of temperature on development is very marked; the blackening and the contrast of the plates both increase with the temperature. Intensification, especially with mercury and ammonia, increases the contrast. Reduction by prussiate of potash alters but slightly the contrasts, but they are weakened by ammonium persulphate. Blackening curves and curves of sensitiveness are given for lights of different wave-lengths, and the effects of erythrosin, eosin and Congo-red are examined in detail.

The author compares his results with those of Hurter and Driffield, criticising the latter's system of sensitometry and their "development constant." G. H. B.

2158. *Zeeman Phenomenon.* **H. M. Reese.** (Elect. World and Engineer, 36. pp. 248–249, Aug. 18, 1900. Abstract of paper read before the N.Y. meeting of the American Physical Association and the A.A.A.S.)—To determine whether the separation was strictly proportional to the strength of the field, a number of photographs were taken of the same lines with fields ranging from 6,000 to 27,000 c.g.s. units. Zinc and cadmium lines were tested together, the spark-gap having terminals of cadmium and zinc respectively. These and the corresponding magnesium lines offer unusually wide separation and a considerable variety of complexity. In the case of the sharp triplets the proportionality between field intensity and separation is very nearly exact. The sextuplets show a separation which increases less rapidly with the field when the latter becomes very intense, and in the "diffuse triplets" this tendency is much more marked. At the same time the shading towards the red is considerably reduced, and all the lines become sharper. The author has not been able to verify all the cases of asymmetry noted by Zeeman. He has, for instance, observed no lines in which the violet component is the stronger. But in all cases where asymmetry was observed the author found that it disappeared on increasing the field strength, as Voigt's theory indicates. E. E. F.

2159. *Spectra of Oscillating Discharges.* **G. A. Hemsalech.** (Journ. de Physique, 9. pp. 437–444, Aug., 1900.)—The author, in continuation of his previous work [see Abstracts Nos. 1428 and 1651 (1900)], has provided a much more powerful spectroscope for the photography of spectra. Reproductions are given of twelve spectra, showing the gradual changes produced in the spectrum of an ordinary induction spark by introducing self-induction into the secondary circuit. With regard to possible work by Thalén in this respect, he shows that the presence of an iron core in the self-induction coil destroys the oscillations almost completely, and therefore the effects observed by Thalén with an electromagnet having an iron core could not have been identical with those now described. C. P. B.

2160. *Spectrum of Radium.* **C. Runge.** (Ann. d. Physik, 2. 4. pp. 742–745, Aug., 1900.)—The author criticises the fifteen spectrum lines ascribed by Demarçay to radium [see Abstract No. 55, (1900)]. He points out that the accuracy with which these fifteen lines were determined is not very great, the error being about 0·7 of an Angström unit. Hence Demarçay's line 4683·0

might be anywhere between 4682·3 and 4683·7. But in this interval there are no less than six Fraunhofer lines, according to Rowland, and that makes the evidence for the separate identity of radium much feebler than it was. The author has therefore redetermined the spectrum of radio-active barium chloride with a greater dispersive power than that employed by Demarçay, and has definitely located three of Demarçay's lines. These are situated at 4826·14, 4682·346, and 3814·591 respectively. The remainder were either invisible or were found in the spectrum of barium chloride when free from radium. An economical method of obtaining the spectrum was that of dipping a thin platinum wire into the powdered preparation and heating the wire by means of an electric current until a bead was formed, which was then made an anode in a spark-gap. But it is possible that the luminous intensity attained was not great enough to reveal some of the feebler lines described by Demarçay. But the three lines mentioned above are definitely established, and they are not contained in the solar spectrum. E. E. F.

2161. *New Spectra of the Rare Earths.* **E. Demarçay.** (Comptes Rendus, 131. pp. 387–389, Aug. 6, 1900.)—Pure terbium peroxide is much darker than has been supposed; the author has obtained a specimen nearly black. In purifying the double nitrate of gadolinium and magnesium, he has prepared from the mother liquors a dark brown peroxide yielding spark lines which appear peculiar to terbium, and are also found in terbias from other sources. Three separate groups of rays obtained from other fractionations he considers due to three new elements; the measurements are given. S. R.

2162. *Spectra of Mixtures.* **C. J. Rollefson.** (Phys. Rev. 11. pp. 101–104, Aug., 1900.)—A photographic study by means of a modified Foley's apparatus, which is figured, of the effect on the spectrum of a metal of the introduction of the salt of another metal into the arc. In some cases the lines are widened and altered in intensity. S. R.

2163. *Absorption Spectra of Ammonia, Methylamine, Hydroxylamine, Acetaldoxime and Acetoxime.* **W. N. Hartley** and **J. J. Dobbie.** (Chem. Soc., Journ. 77. and 78. pp. 318–327, April, 1900.)—Even after many re-crystallisations as ammonium sulphate, ammonia still shows a dark band in its absorption spectrum. The authors find, however, that no selective absorption is shown by ammonia obtained from the reduction of hydroxylamine or from ammonium oxalate purified by crystallisation. The addition of pyridine causes the reappearance of the absorption band. The absorption spectra of methylamine, hydroxylamine, acetaldoxime and acetoxime in solutions of various concentrations are also given. T. H. P.

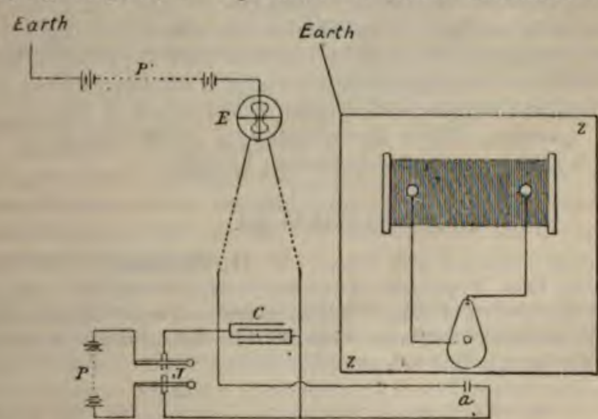
2164. *Absorption Spectra of the Ethyl Dibenzoylsuccinates.* **W. N. Hartley** and **J. J. Dobbie.** (Chem. Soc., Journ. 77. and 78. pp. 498–509, April, 1900.)—The absorption spectra of the ethyl α-, β-, and γ-dibenzoylsuccinates are given. The curves for the β- and γ-compounds are identical and differ considerably from that of the α- or enolic ester. These results are in accord with the structural formulæ arrived at by Knorr (Annalen, 1896, 293, p. 70) on purely chemical grounds. T. H. P.

2165. *Absorption Spectra of Benzantialdoxime and Benzsynaldoxime.* **W. N. Hartley** and **J. J. Dobbie.** (Chem. Soc., Journ. 77. and 78. pp. 509–512, April, 1900.)—The absorption spectra of benz-antialdoxime and -synaldoxime

are found to be identical ; the conclusion previously arrived at that stereo-isomerides, unlike isomerides differing in structure, give identical absorption spectra, is thus borne out.
T. H. P.

2166. *Uranium Rays.* **H. Becquerel.** (Comptes Rendus, 131. pp. 137–138, July 16, 1900.)—When uranium chloride is mixed with barium chloride, and the barium is precipitated as sulphate, the latter takes down with it the greater part of the radio-activity of the uranium. The question remains as to whether a further application of the same process would eventually result in the uranium being made entirely inactive. The author has therefore applied the same process eighteen times over to the same specimen. He found that the barium sulphate precipitated was less and less active, and that correspondingly the loss of activity of the uranium became less and less in proportion to its initial activity. Between the eighth and twelfth operation the variations in activity were sometimes positive and sometimes negative, and could possibly be due to the presence of more or less water, as the salt is hygroscopic. In the case of the unpurified product, aluminium is more transparent for the rays than glass, but the case is reversed in the purified uranium, whose rays obey rather the rules of light than those of Röntgen rays in the matter of absorption. After the fifteenth operation another decided diminution of activity sets in, bringing it down to one-sixth of the original activity. What happens after the eighteenth operation is not yet known.
E. E. F.

2167. *Discharge of a Condenser by Röntgen Rays.* **F. Campanile** and **G. di Ciomme.** (Phys. Zeitschr. 1. pp. 401–407, June 23, 1900.)—In the accompanying diagram, C represents an Elliott microfarad condenser



charged by a battery P of 40 small Daniell cells, and discharged through a gap *a* between copper points or discs. E is an electrometer charged by 100 volta elements P′, and Z is a metallic box containing the whole apparatus for generating Röntgen rays, and put to earth. It was found that at all potentials the discharge is accelerated by the Röntgen rays. Although the quantities discharged by the Röntgen rays become smaller as the potential decreases, the rays are comparatively more effective at the lower than at the higher potentials. The capacity of the condenser has a marked influence upon the quantity discharged. The quantity is great in the case of small capacities, decreases to a minimum with increasing capacity, and then increases again.
E. E. F.

2168. *Radio-activity in Barium Salts.* **A. Debierne.** (Comptes Rendus, 131. pp. 333–335, July 30, 1900.)—Actinium is employed in producing radio-activity which happens to be but feeble in barium salts. The induced activity, as with radium and thorium, depends on the nearness and duration of action of the inducing substance. Intimate contact is secured by putting the substance to be rendered active in solution with the active body or by precipitating the two together. It is found that the artificially radio-active barium and radiferous barium extracted from pitch blend have some common properties: the radio-activity persists through chemical transformations; the rays from both substances ionise gases, excite phosphorescence in Ba Pt Cy., and affect photographic plates. Further, a part of the radiation is deviated in the magnetic field, and the anhydrous chloride is luminescent. On the other hand, the "activated" barium does not give the radium spectrum, and its activity diminishes with time. G. E. A.

2169. *Fluorescence of Quinine.* **G. C. Schmidt.** (Phys. Zeitschr. 1. pp. 466–467, July 28, 1900.)—It was pointed out by Stokes that the fluorescence of quinine is destroyed by hydrochloric, hydrobromic, and hydriodic acids, and by salts of these acids. After investigating this behaviour E. Buckingham came to the conclusion that only the quinine-ions were able to fluoresce, and that the fluorescence was destroyed by hologen-ions from any source. From experiments on the absorption-spectrum of quinine sulphate before and after adding haloid salts, the author concludes that the hologen-ions do not produce any chemical changes in the quinine. As they destroy the fluorescence of quinine it seemed desirable to examine whether they reduce its chemical reactivity. To test this, quinine sulphate was dissolved with addition of sulphuric acid and known quantities of haloid salts; the solution was then placed in sunlight to see whether any conversion into cinchonine took place (a change which could be followed with the polarimeter). The results show that the decomposition of quinine is hindered by the presence of halogen-ions, and may be entirely prevented by them if they are present in sufficient quantity. When the quantity is great enough to prevent fluorescence it also prevents decomposition by light. D. E. J.

REFERENCES.

2170. *Formulæ Connected with Lenses.* **T. H. Blakesley.** (Phil. Mag. 49. pp. 447–453, May, 1900. Paper read before the Physical Society of London.)—This paper contains the solution of some problems in practical optics connected with the combination of lenses or of mirrors and lenses. The method used is Abbé's familiar one of using only the principal foci and the focal length of each optical combination in the system, quite irrespective of the elements of which the combinations may be built up. J. B. H.

2171. *Binocular Magnifying-Glass.* **E. Berger.** (Zeitschr. Instrumentenk., Beib. pp. 53–56, March 15, 1900.)—This paper deals with the theory of the binocular magnifying-glass described in Abstract No. 620 (1900). J. B. H.

2172. *Uranium, Radium, and Metallic Emissions.* **G. le Bon.** (Revue Scientif. 13. pp. 548–552, May 5, 1900.)—The announcement by the author some years ago, that metals in certain conditions emit radiations, is claimed as having begun the study of radio-active bodies. As uranium rays in common with other metallic rays are not polarised, and as chemical analysis does not prove the existence of new bodies, the author disputes the existence of radium and polonium, and explains radio-activity as the emission of dissociated atoms. G. E. A.

2173. *Colour Perception.* **W. Heinrich.** (Acad. Sci. Cracovie, Bull. pp. 64–92, Feb., 1900.)—A critical and historical review of the methods of investigation of colour perception. G. E. A.

2174. *Lummer-Brodhun Photometer.* **O. Lummer** and **E. Brodhun.** (Phil. Mag. 49. pp. 541–543, June, 1900.)—Reply to the paper by C. G. Knott referred to in Abstract No. 481 (1900).

2175. *Formulæ for Lenses.* **B. Wanach.** (Zeitschr. Instrumentenk. 20. pp. 161–171, June, 1900.)—This paper contains the development of formulæ for calculating the path of rays of light through a centric system of lenses. The formulæ are also applied to the case of a photographic objective. J. B. H.

2176. *Atmospheric Refraction.* **A. Gleichen.** (Deutsch. Phys. Gesell., Verh. 2. 2. pp. 24–36, 1900.)—This paper contains a mathematical study of the refraction which a pencil of rays emanating from a point outside the atmosphere suffers on passing through the atmosphere. The positions of the primary and secondary focal surfaces are investigated and applied to the case of lunar eclipses to account for the illumination of the moon's surface during eclipse. J. B. H.

2177. *Wave Theory of Light.* **A. Cornu.** (Cambridge Phil. Soc., Trans. 18. pp. 17–28, April, 1900. Rede Lecture.)—The lecturer sketches the development of the wave theory from the time of Descartes to the present day, and dwells upon the profound influence which this theory, and optics generally, have exerted upon the progress of physics. E. E. F.

2178. *Spectral Apparatus.* **H. Lehmann.** (Zeitschr. Instrumentenk. 20. pp. 193–204, July, 1900.)—This paper contains a description of the different methods of using the grating spectral apparatus in which the telescope, or camera, and the collimator remain fixed, while the grating is rotated. The greater part of the paper is devoted to a mathematical study of the dispersion obtained in different arrangements, and the publication is intended to form a guide in the use of the apparatus of this type made by Steinheil. J. B. H.

2179. *Grating Films and Colour Photography.* **T. Thorp.** (Manchester Lit. and Phil. Soc., Mem. 44. 12. pp. 1–8, 1900.)—An account is given of the preparation of celluloid casts from a Rowland metal diffraction grating and the application of these to photography in colours. J. J. S.

2180. *Becquerel Rays.* **H. Starke.** (Zeitschr. Instrumentenk. 20. pp. 212–220, July, 1900.)—An historical *résumé* and an enumeration of the chief properties of the rays, with some reference to the emission theory. G. E. A.

2181. *Refraction and Magnetic Rotation of Hexamethylene and of Chloro- and Dichloro-Hexamethylene.* **S. Young** and **E. C. Fortey.** (Chem. Soc., Journ. 77. and 78. pp. 372–374, April, 1900.)—The results of redeterminations of these constants by W. H. Perkin, sen., are given. T. H. P.

HEAT.

2182. *Relation of Specific Heats of Metals to their Atomic Weights.* **W. A. Tilden**, with Appendix by **J. Perry**. (Roy. Soc., Proc. 66. pp. 244–247, April 14, 1900; Roy. Soc., Phil. Trans. 194. pp. 233–255, June 6, 1900.)—Results are given of the measurement of the specific heats of specially purified nickel and cobalt by means of Joly's steam calorimeter. The mean specific heat of cobalt between 15° and 100° is 0·10303, the value for nickel being 0·10842. Taking 55·55 and 58·24 for the respective atomic weights, the numbers for the atomic heats become 6·03 and 6·31, so that Dulong and Petit's law cannot be taken as strictly applicable at all temperatures. Gold and platinum represent another pair of metals with nearly equal atomic weights and densities; the specific heats (between 15° and 100°) are 0·03035 and 0·03147 respectively, so that the atomic heats have very different values. Determinations of the specific heats of several impure samples of iron and copper show that the specific heat of a metal is raised appreciably by the presence of small quantities of a non-metallic impurity, whilst the presence of a second metal produces very little effect on the specific heat until the quantity of it is large enough to be felt through the difference of atomic weight. The specific heat of pure copper is 0·9232 and that of iron 0·10983 for the limits of temperature 15° and 100°. Calorimetric measurements made by the method of mixtures on pure nickel and cobalt at low temperatures show that as the temperature falls the specific heat of nickel diminishes more rapidly than that of cobalt, the two values gradually becoming more and more nearly equal. The following table gives the mean specific heats for the different ranges of temperature:—

Temperature.	Cobalt.	Nickel.
From 100° to 15°	0·10303	0·10842
„ 15° to — 78·4°	0·0939	0·0975
„ 15° to — 182·4° ...	0·0822	0·0838
„ — 78·4 to — 182·4°	0·0712	0·0719

The atomic heat at — 273° C. is for both metals about 4, and it is probable that at this temperature the specific heats would be inversely proportional to their atomic weights. The variations of the specific heats of nickel and cobalt with the temperature are expressed with good agreement by the following formula, deduced by Perry:—

$$K = k_0\left(1 + \frac{bt^n}{c + t^n}\right)$$

where K is the specific heat, t the temperature on the absolute scale, and k_0, b, c, and n constants, which for cobalt have the values 0·0412, 1·695, $1·002 \times 10^6$, and 2·73 respectively, whilst in the case of nickel the numbers are 0·0415, 1·892, $0·932 \times 10^6$, and 2·68 respectively. T. H. P.

2183. *Boiling-points of Zinc and Cadmium.* **D. Berthelot.** (Comptes Rendus, 131. pp. 380–382, Aug. 6, 1900.)—An interference method, described in 1895, is used. The mean of five determinations for pure zinc gives 920°. The mean of three for cadmium is 778°. Previous results are mentioned.

G. E. A.

2184. *Electric Pyrometers.* **J. A. Montpellier.** (Électricien, 20. pp. 97–100, Aug. 18, 1900.)—This paper is a description of the electric pyrometers for high and low temperature, exhibited by Hartmann and Braun at the Paris Exhibition. For temperatures up to 400° C. the change of resistance in a wire spiral is measured by an ohmmeter reading direct in degrees Centigrade. For temperatures from 400° to 1,600° C. a thermocouple is used with a millivoltmeter. The couple used for temperatures from 400° to 1,000° C. is platinum and an alloy of platinum and nickel, and for temperatures from 1,000° to 1,600° C., platinum and an alloy of platinum containing 10 per cent. rhodium. The construction of the pyrometer is new; it consists of a number of short cylinders of refractory material held together end to end by a central metal rod. The thermocouple wires pass through longitudinal holes in the cylinders. It is claimed that the cylinders remain in place even though one or more may crack. G. H. B.

2185. *The Determination of γ by Observations on the Dew-point.* **R. Cozza.** (Archives des Sciences, 10. pp. 132–143, Aug., 1900.)—The author used a metal cylinder, closed at each end by glass plates, in which to conduct the compression of the moist gas so that the deposition of moisture in the gas could be easily perceived when the dew-point was reached. The cylinder had three tubes leading from it—one to a pump, a second to a manometer for registering the pressure, and a third, closed by a stopcock, by which the cylinder could be placed in communication with the outer air. A thermometer outside the cylinder completed the apparatus. To conduct an experiment the cylinder is filled with air, and by means of the pump this air is compressed, and when the heat produced by the compression has been dissipated, the stopcock leading to the open air is opened suddenly, and the consequent expansion causes a cooling of the air. If this cooling be sufficient the dew-point is reached and a cloud is seen in the cylinder. Observations are made with gradually decreasing amount of compression until that point is reached when only the faintest cloud is visible on opening the stopcock.

Using the formula—

$$T_2 = T_1\left(\frac{p_2}{p_1}\right)^{\frac{C-c}{C}}$$

where—

T_1 = initial temperature,
p_1 = pressure before opening stopcock,
p_2 = pressure of external air,
T_2 = dew-point,

the value of $\frac{C-c}{C}$ can evidently be obtained.

In two methods employed the following results were obtained:—

p_2.	p_1.	T_1.	T_2 1st method.	T_2 2nd method.	γ from 1st.	γ from 2nd.
729	962	295	272·5	274·0	1·400	1·363
722	933	295	272·5	274·0	1·447	1·405
726	916	295·4	273·0	274·3	1·512	1·467
703	916	294·5	272·0	273·6	1·427	1·389
706	904	294·0	271·5	273·0	1·473	1·426

W. C. O.

2186. *Temperature Gradient in Flames.* **H. Mache.** (Akad. Wiss. Wien, Sitzb. 108. pp. 1152–1160, 1899.)—This is a physical investigation of the temperature gradient in a homogeneous burning mixture of gases, such as a detonating mixture of oxygen and hydrogen. If such a mixture is contained in a tube, and an explosion started at one end, the explosion travels along the tube with a definite velocity. The surface separating the exploded from the unexploded portion is the "burning surface." On one side of this surface the gases have the temperature of combustion, on the other they have the temperature of ignition. The transition from the one to the other is abrupt, being distributed over a distance of molecular dimensions. When the gases issue from an orifice, the velocity with which they issue is opposed to the velocity of propagation of the burning surface, and the latter becomes stationary. To determine the distribution of temperature, the author considers the burning surface MN (see diagram), against which the gases stream in the direction of the

arrow, with a velocity equal to the velocity of explosion c. By the time the gas reaches MN it has been heated up to the ignition temperature τ by conduction from the gases burning at a temperature T. There must be a definite gradient of temperature along x. For $x = \text{inf.}$, the temperature U is the initial temperature t of the mixture. For $x = 0$, $U = \tau$. Let two adjacent strata have the temperatures U and $U + dU$. If k is the conductivity, then $-k\frac{\partial U}{\partial x}$ is the amount of heat passing unit surface in unit time. Of that amount $k\frac{\partial^2 U}{\partial x^2}$ remains behind in unit volume. Now, if the temperature is to be stationary, the gas of temperature U must be so often renewed by the gas of temperature $U + dU$ that the quantity of heat $k\frac{\partial^2 U}{\partial x^2}dx$ just suffices to bring the incoming gas up to a temperature U. If ρ is the density, and C the specific heat at constant volume of the gas, and the layer must be renewed n times in unit of time, we have—

$$-n\,dx\rho C\,dU = k\frac{\partial^2 U}{\partial x^2}dx.$$

The author works out a solution of this equation, and shows that the temperature decreases rapidly upwards from the burning surface, being 600° at 12 cm. distance from it, 200° at 65 cm., and 50° at 122 cm. He also shows how to investigate the thickness of the exploding layer. He determines the amount of heat which would pass it if the ignition layer and the layer of complete combustion immediately joined each other, and shows that that quantity is of the same order as that which actually passes, and not very different numerically. For hydrogen the coefficient of this abrupt change of temperature is–

$$\gamma = \frac{(T-\tau)k}{c_0\rho_0\gamma_0\tau} = 0{\cdot}002.$$

E. E. F.

2187. *Saturation Curve of Carbonic Acid.* **E. H. Amagat.** (Com Rendus, 131. pp. 91–92, July 9, 1900.)—In his studies on carbonic acid m in 1892, the author found that the diameter of the curve of liquid and vap densities at saturation was a straight line, and also that the locus of the po for which the volumes of the liquid and the vapour are equal was a stra line. Mathias, on the other hand [see Abstract No. 1441 (1900)], found this locus was not a straight line, but a curve which very nearly coinci with its tangent at the critical point. The two loci in question having b constructed with the same experimental material, there is no reason to supp that the one is more real than the other. Both may be practically rectilin but they cannot both be mathematically so. The law discovered by Caill and Mathias is useful in all researches concerning critical constants, and author has himself obtained some figures which show that for a cer number of substances and between wide limits of temperature the diam is practically a straight line, but it is clear that bodies are known for wh the diameter in question is curvilinear. E. E

2188. *Maximum Pressure of Camphor Vapour.* **R. W. Allen.** (Ch Soc., Journ. 77. and 78. pp. 413–416, April, 1900.)—The vapour pressure camphor, determined by the two methods described in the following Abstr are given. The values obtained in the two cases are concordant, those gi by the evaporation method being as follows :—

Temperature.	Vapour Pressure.
15·6°	0·14 mm. mercury.
35·0°	0·33 „
45·0°	0·91 „
49·0°	1·23 „
75·0°	6·59 „

These numbers differ considerably from those of Ramsay and Young (P Trans., 1884, i. p. 45). T. H

2189. *Maximum Pressure of Naphthalene Vapour.* **R. W. Allen.** (Ch Soc., Journ. 77. and 78. pp. 400–412, April, 1900.)—The author gives results of measurements of the vapour pressure of naphthalene at vari temperatures, the methods employed being (1) the ordinary barome method, and (2) the evaporation method, in which a known volume of indifferent gas at a definite temperature is passed over a weighed quantity the naphthalene, the loss of which is determined at the end of the experim The values obtained by method (2) are—

Temperature.	Vapour Pressure.
15°	0·066 mm. mercury.
30°	0·135 „
45°	0·51 „
60°	1·81 „
75°	5·43 „

The first method gives numbers agreeing well with the above, the val for other temperatures being—

Temperature.	Vapour Pressure.
0°	0·01 mm. mercury.
78·4°	7·01 „
80·4°	7·54 „
100°	18·50 „
116°	36·87 „
130°	61·95 „

T. Y

2190. *Vapour-pressure, Heat of Vaporisation and Triple Points of Bromine and Iodine.* **K. Tsuruta.** (Phys. Zeitschr. 1. pp. 417–419, June 30, 1900.)—By interpolation a table of vapour pressures for bromine between — 16° and 55°, and for iodine from 60° to 180°, has been obtained. The heat of vaporisation of bromine at the boiling-point is calculated from Clausius' formula to be 45·3, whilst the mean experimental value is 44·9 cal. The melting-point is calculated to alter 1° C. for each 49·20 atmospheres in the case of bromine, and for each 31·78 atmospheres in the case of iodine. T. M. L.

2191. *Law of Corresponding States.* **D. Berthelot.** (Comptes Rendus, 131. pp. 175–178, July 16, 1900.)—The suggestion has often been made that this law would be more exact if temperatures and specific volumes were measured from special "zeros," which differ for different bodies, but are not 0. For the bodies studied by S. Young the author finds the following special zeros, those for temperatures being expressed in degrees C., and those for specific volumes in cc. per grm. :—

	t_m	v_m		t_m	v_m
C_6H_6	46·6	0·892	CCl_4............	40	0·490
C_6H_5Fl	56	0·767	Ether	51·4	1·019
C_6H_5Cl	61	0·734	CO_2	21	0·599
C_6H_5Br.........	69	0·554	Pentane	46	1·171
C_6H_5I	72	0·459	Isopentane...	43·3	1·179

These are confirmed by comparison with Mme. K. Meyer's results [see Abstract No. 1049 (1900)]. R. E. B.

2192. *Molecular Theory of Gases.* **M. Brillouin.** (Annal. Chim. Phys. 20. pp. 440–485, Aug., 1900.)—This is a study by Maxwell's 1879 method, but without the assumption that the force acting between molecules during an encounter varies inversely as the fifth power of their separation. Taking the distribution of speeds to be $\phi(1 + \zeta)$, where ϕ is Maxwell's distribution for the case of equilibrium, and ζ is a complementary factor due to the flow of the gas and the propagation of heat in it, the author finds that ζ is directly affected by the external field of force, which has consequently a direct effect upon the viscosity, thermal conductivity, &c., of the gas, the exact nature of which depends on the law of action between molecules ; and he thinks that the terms depending upon density that his analysis has introduced have an important place in the theory of flame in determining the region separating combustion from explosion. R. E. B.

2193. *Adiabatic Expansion of Wet Steam.* **F. W. Arnold.** (Inst. Civ. Engin., Proc. 140. pp. 221–225, June, 1900.)—It is known that the law $pv^\gamma = c$ does not hold for the adiabatic expansion of wet steam ; it is, however, nearly true in many cases, the value of γ depending upon the range of initial temperature and initial dryness. The author found it necessary to find the value of γ for steam of various drynesses and temperatures, usually over a range of 80° C. For each mean temperature a curve was plotted with the initial drynesses as abscissæ, and the corresponding values of γ as ordinates ; another set of curves was drawn, one for each initial dryness, with the mean temperatures as abscissæ and corresponding values of γ as ordinates. The following expression is obtained, which holds within 1 per cent. if the mean

temperature θ lies between 80° and 180° C., and the initial dryness x_1 is greater than 0·2—

$$\gamma = 1{\cdot}125 + \frac{2\theta + 140}{2000}\left(\frac{0{\cdot}0323}{x_1^2} - \frac{0{\cdot}449}{x_1} + 0{\cdot}459\right)$$

No attempt is made to give an equation showing the variation of γ, taking into account all the intricacies. A. S.

2194. *Problem in the Theory of Heat, proposed by F. Kohlrausch.* **W. Voigt.** (Gesell. Wiss. Göttingen, Nachr., Math-Phys. Klasse, 3. pp. 228–239, 1899.)—Kohlrausch, in a work "on the stationary temperature of a conductor heated by the electric current" (Berlin Berichte, xxxviii. p. 711, 1899), treats the problem of a conductor on whose surface two regions are maintained at different constant temperatures and potentials, the rest of the surface being isolated for heat and electricity. The author gives a solution of the problem, taking into consideration the "Thomson effect" of which Kohlrausch had not taken account. The solution is founded on the author's own former works (Gött. Nachr., 1895, p. 135; 1898, p. 113; Wied. Ann. 67. p. 717), the present problem offering an example of his methods. If T denote the absolute temperature, Θ a function of T depending on the nature of the substance, Δ the conductivity for heat, λ that for electricity, we have—

A thermoelectric component of force, $X = \frac{\partial\Theta}{\partial x} = \frac{d\Theta}{dT}\frac{\partial T}{\partial x}$ (1)

A component electric current, $u = -\lambda\frac{\partial(\Phi - \Theta)}{\partial x}$ (2)

A component current of heat, $U = -\Delta\frac{\partial T}{\partial x}$ (3)

And a convection current of heat attendant on the electric current, $U = -uT\frac{d\Theta}{dT}$ (4)

These are the fundamental equations of the theory. S. H. B.

SOUND.

2195. *Propagation of Sound.* **A. W. Duff.** (Phys. Rev. 11. pp. 65–74, Aug., 1900.)—In 1898 [see Abstract No. 777 (1898)] the author described a method of determining the attenuation of sound with distance which was based upon the employment of a number of whistles of equal loudness, and the distance at which a certain number of them became inaudible. To test the rapid decay of intensity then found, the author has since employed another method, consisting in the comparison of the intensity of a whistle at a certain distance with the intensity of the same sound as transmitted by a telephone. Points were found at which both were equal. A whistle of pitch 4,000 was found most suitable, as small differences of quality were less disturbing at that pitch. Within the limits of error the following theoretical laws for the intensity S were verified :—

For small distances r—

$$S=\frac{1}{r^2}\left(1+\frac{a^2}{n^2r^2}\right)$$

For large distances—

$$S=\frac{e^{-2mr}}{r^2}$$

where a is the velocity of sound, n the pitch, and m the sum of three terms involving the viscosity, thermal conduction, and radiation respectively of the medium. The value of m found is 0·000033. E. E. F.

2196. *Production of Sound in Organ-Pipes.* **V. Hensen.** (Ann. d. Physik, 2. 4. pp. 719–741, Aug., 1900.)—In a sounding organ-pipe the air is carried upwards by the inner secondary current within the pipe. A kind of air-sheet is formed next the tongue of the pipe, and the air is exhausted near the mouth. This exhaustion forces the air blown into the pipe to return to the mouth, even if the pipe is open at the top. In doing so the returning air throws the air-sheet into periodic motion. The air-sheet behaves like an incompressible fluid. This theory is illustrated by various experiments with flames and air-blasts. E. E. F.

2197. *The Graphophone Grand.* (Frank. Inst., Journ. 150. pp. 17–34. Supplement by **P. Mauro**, pp. 35–43, July, 1900.)—The graphophone grand is a modification of the graphophone of Bell and Tainter. In the latter instrument the records are scratched upon a revolving cylinder of paper coated with a specially prepared wax by means of a sharp style, the vibrations of the style taking place radially to the surface of the cylinder, so that the result is a spiral groove of varying depth, while the style is so arranged that at no time does it leave the surface of the wax, and thus removes a continuous ribbon of its substance.

The chief modifications which have been introduced in the instrument of Macdonald are :—

(1) An increase in the velocity with which the style is made to pass over the recording surface, thereby ensuring undulations of a greater amplitude with long, gentle, easy strokes, as distinguished from the records of the same sound having short, abrupt undulations. (2) The style is set at a more acute

angle to the recording surface. (3) The diameter of the cylinder is made greater for the reason that the higher speed can be more easily obtained in this way than by an increased angular velocity. The surface velocity is increased two and a half or three times, and the effect that this will produce upon the working of the instrument may be considered thus :—

The cutting style performs its pendulous motions and cuts in the wax a line composed of alternate elevations and depressions. As the cutting edge begins to descend it at first encounters practically no resistance, the sharp edge only being in contact with the material of the tablet, but as the movement continues the crest just being formed comes in contact with the shank of the style, and a check is imposed upon the further penetration of the instrument.

If the surface velocity be high, the slopes are more gentle, and the crests of the undulations as they are formed are carried away so quickly that they do not come in contact with the shank, and thus no check being received the style is enabled to penetrate more deeply, and the amplitude of the vibrations recorded on the tablet is greater.

The greater velocity entails more wax being cut away in a given time, and hence more work being done, but this is overcome by giving the style a sharper angle of incidence upon the wax and a keener edge. With the low-speed records the crests, when close together, did not afford the point of the reproducing style opportunity of descending fully into the intervening depressions ; moreover, when an abrupt ascending slope impinged against the reproducing point the style was thrown off the record, and an interruption of the tracing operation ensued. W. C. O.

2198. *Flutings in the Kundt Sound Tube.* **S. R. Cook.** (Amer. Assoc., Proc. 48. pp. 121–122, 1899.)—The author performed experiments with the object of verifying König's equations for the forces acting to produce flutings in the sound tube. Various materials were tried as fluting substances—magnesium carbonate, lycopodium, amorphous silica, cork dust, magnesium, anthracene, ammonium-chloride fumes, sand, aluminium, iron, brass, copper, coin silver, &c.—the laminæ being examined by the microscope. The equations when worked out give repulsion parallel to the stream lines and attraction perpendicular to the same. In experiments with air and carbon dioxide, when the forces of attraction in the two were made equal, and also the forces of repulsion, the ratio of the densities varied from 0·42 for magnesium carbonate to 0·82 for sand. The ratio of the density of hydrogen to air for the same effect was 5·85. W. C. O.

ELECTRICITY.

THEORY AND ELECTROSTATICS.

2199. *Kinetic Theory of Metallic Conduction.* **M. Reinganum.** (Ann. d. Physik, 2. 2. pp. 398–403, June, 1900.)—The ratio of the thermal and electrical conductivities of a metal may be approximately calculated by Drude's electron theory [see Abstract No. 1276 (1900)], which involves the number of gaseous molecules per gramme and Thomson's value of the elementary electric charge. The author points out that these two numbers, both somewhat roughly determined, are not really necessary at all, and that the much better known values of the electrochemical equivalent and the velocity of hydrogen atoms in a gas may be substituted for them. This substitution gives for the ratio of thermal to electric conductivity the number $0{\cdot}7099 \times 10^{-10}$, which is in remarkably close agreement with the experimental values found by Jäger and Diesselhorst, such as $0{\cdot}706 \times 10^{-10}$ for aluminium. In this agreement the author sees a proof that in metals also, as in liquids, electricity moves in separate quantities of the same value as the quantities transported by electrolytic ions, and that the principles of the kinetic theory of gases apply to both.

E. E. F.

2200. *Thermal and Electric Conductivities.* **E. Riecke.** (Ann. d. Physik, 2. 4. pp. 835–842, August, 1900.)—Comparing his own formula for this ratio with that of Drude [see Abstract No. 1276 (1900)] the author finds that it differs in the numerical factor, which is $\frac{4}{3}$ in Drude's equation and $\frac{3}{2}$ in his own. The difference is probably due to the circumstance that Drude admits the possibility of collisions between the electrons themselves. Following Drude with regard to the kinetic energy of the ions, the ratio of the thermal and electric conductivities becomes—

$$\frac{k}{\gamma} = \frac{3}{2}\,\frac{\alpha^2 v^2}{\epsilon^2}\,\mathrm{T}(1 + \tfrac{2}{3}\partial'\mathrm{T}).$$

The kinetic theory of gases gives—

$$\alpha = \tfrac{3}{2}\mu\mathrm{R}.$$

Hence—

$$\frac{k}{\gamma} = \frac{27}{8}\,\frac{\mu^2\mathrm{R}^2 v^2}{\epsilon^2}\,\mathrm{T}(1 + \tfrac{2}{3}\,\partial'\mathrm{T}).$$

If μR is a universal constant, and the elementary quantity of electricity ϵ is the same for all monovalent ions, the value of $\mu^2\mathrm{R}^2\nu^2 / \epsilon^2$ may be found by substituting the values as known for hydrogen. This gives—

$$\frac{k}{\gamma} = 9{\cdot}00276 \times 10^{-10} \times v^2\,\mathrm{T}(1 + \tfrac{2}{3}\,\partial'\mathrm{T}).$$

The values obtained from Jaeger and Diesselhorst's experiments on copper are somewhat smaller than the calculated values. E. E. F.

2201. *Electrification by Ice.* **H. Ebert** and **B. A. Hoffmann.** (Ann. d. Physik, 2. 4. pp. 706–718, August, 1900. From the Sitzb. d. k. Bayr. Akad. d. Wissensch.)—In the course of some experiments on liquid air, the authors noticed that a body suspended above the surface of the liquid required a

strong negative charge. A series of test experiments revealed the fact that this charge is not due to the liquid air itself, but to the friction of minute particles of very cold ice suspended in its vapour. The authors even succeeded in constructing a kind of electrifying machine by means of a tube containing a piece of wire gauze through which the vapour of liquid air was driven. This phenomenon of electrification should be allowed for in all experiments with liquid air, as it may account for errors and anomalies. Ice acquires a positive charge by friction with any metal, and imparts to the metal, and to other bodies also, a negative charge. It appears to be the more active, in this respect, the colder and drier it is. This may account for the strong electric effects of polar snowstorms. Even in our latitudes, ascending currents of air soon reach elevations at which all their water freezes, and the friction of the ice crystals against suspended dust particles would account for part of the atmospheric electrification. In the highest regions, a friction between atmospheric ice and cosmic dust, together with solar ionisation and the consequent conductivity of the atmosphere, might account for atmospheric luminescence, and even for the aurora. E. E. F.

DISCHARGE AND OSCILLATIONS.

2202. *Electric Discharge in Gases.* **J. Stark.** (Phys. Zeitschr. 1. pp. 439–442, July 14, 1900.)—In gases conveying an electric discharge, the conductivity varies from point to point, according to the number of ions per unit volume and to their mobility. While in metallic conductors the positive and negative currents, as well as the total current, are the same for every cross section, in gases the positive and negative currents, conveyed by their respective ions, may be very different, even while the total current remains the same. This difference may lead to the formation of strata of positive and negative ions, as in the stratified discharge. There are, in addition to the original electric field, internal charges and stresses which change the relation between E.M.F. and current strength. Originally, the velocity of an ion is proportional to the field. But if the field varies along the path, the proportionality between field and speed is disturbed by what the author terms the "shooting" of the ions, a phenomenon of inertia. The superior velocity of the negative ions gives the kathode a determining influence upon the current strength. In dealing with the electric field within the gas, it is necessary to consider the small fields due to the separate ions, especially in any theory of the luminous phenomena of vacuum tubes. E. E. F.

2203. *Electric Glow in Vacuum Tubes.* **J. Stark.** (Phys. Zeitschr. 1. pp. 396–400, June 16, 1900.)—The regions of luminosity in a vacuum tube are those in which the potential gradient is a relative maximum. In a gas subjected to electric discharge, there are layers in which there is an excess of positive over negative ions and *vice versâ*. In any given region of maximum potential gradient the surface next the anode is positive, and that next the kathode negative. The occurrence of positive and negative layers is caused by the difference in the velocities of the positive and negative ions. In a region of maximum gradient positive ions are driven into a negatively electrified space, and negative ions into a positively electrified space. Since the negative ions travel faster, it is almost as if the positive ions stood still and the negative ions moved towards them. Hence the relative motion of the two classes of ions has a maximum nearer the kathode than the anode in any given region of

maximum potential gradient. In a region of minimum gradient, on the other hand, there is very little relative motion of ions, since practically only negative ions traverse it. The regions of maximum potential gradient are also regions of maximum ionisation, since the electric separating force is strongest there.

The author sketches the probable mechanism of the glow produced by electric discharge. When an electron is subject to a sudden impulse whose duration is short in comparison with its own period of vibration, it is put into vibration. Such an impulse results from a sudden disturbance of the electro-magnetic field immediately surrounding it, such as might be produced by the passage or impact of an electron of the opposite sign. The author distinguishes between accidental encounters, produced by the original motion of the electrons, and forced encounters, produced by their mutual attraction. The former are directly proportional to the density, and therefore to the pressure of the gas. The latter are nearly proportional to the product of the electrons encountering each other, and therefore increase very rapidly towards regions where there is a maximum relative motion of positive and negative electrons. Des Coudres' experiment, showing an increased luminosity produced by kathode rays impinging upon a positive screen, and a diminished luminosity when they impinge upon a negative screen, is explained by the forced impact in the former case. Since the damping of the vibration is the less the more sudden the impact, it follows that electrons produce the greater luminosity the more rapid their motion, and any increase of speed probably also produces a shifting of the spectrum towards the violet end. E. E. F.

2204. *Helical Vacuum Discharge.* **E. Ruhmer.** (Phys. Zeitschr. 1. pp. 407–409, June 23, 1900.)—The author describes a beautiful new vacuum phenomenon. It is best obtained with a glass tube 1 m. long and 4 cm. wide, provided with projector-shaped aluminium mirrors, 2·8 cm. in diameter, attached to platinum wires at the two ends of the tube. The tube is exhausted to such an extent that the sparks from a 30 cm. coil mounted in parallel just pass the air-gap at 15 cm. distance instead of through the tube. The current used is taken from mains at 110 volts, and is passed through a Wehnelt interrupter. The discharge in the tube has the shape of a red stripe about 1 cm. thick passing straight from one electrode to the other. If then the current is reduced, the stripe breaks up into a succession of glowing patches, and on grasping the tube round the middle, with the positive pole upwards, the discharge falls into the shape of a screw of about six turns, which slowly rotates about its axis. The hand can then be removed, and the phenomenon continues. The screw has sometimes a diameter of 2·5 cm., and is then left-handed. Sometimes its diameter is smaller (0·5 to 1 cm.) and then it is right-handed. But in any case it rotates so as to appear to descend, completing a turn in about seven seconds. The discharge proceeds from fixed points on the electrodes, which do not change during rotation. The pitch depends upon the current strength and the rate of interruption. No explanation is offered as yet. E. E. F.

2205. *High-Frequency Discharges.* **N. Tesla.** (Nature, 62. pp. 116–117, May 31, 1900. Abstract of part of a paper in the Century Magazine, June, 1900.)—A popular description of high-frequency discharges of unusual length, up to 60 or 70 feet. The air is distinctly conducting to such discharges. This conductivity increases very rapidly with rarefaction, so that there is a possibility of utilising the upper strata of the atmosphere at very moderate altitudes for the transmission of electrical energy. W. R. C

2206. *Sparking Distances and Radiation.* **S. Attilio.** (Rivista Sci.-Industriale, 32. pp. 97–100, May 10, 1900.)—The author investigates the influence of the radius of curvature of the terminals of a spark-gap upon the action of ultra-violet light in favouring the discharge. He notes a decided influence of the curvature upon the "neutral distance" between the terminals, at which the light neither impedes nor favours the discharge. With a negative electrode of radius 4 cm. the neutral is about 1 cm. an impeding action setting in above that value. The neutral distance increases as the radius of curvature diminishes, until the impeding action disappears. The latter action is, in general, only obtained with negative electrodes of aluminium or amalgamated zinc. E. E. F.

2207. *Loss of Electric Charge by Evaporation.* **A. Pochettino** and **A. Sella.** (Accad. Lincei, Atti, 9. pp. 3–10, July 1, 1900.)—To decide the question whether the evaporation of a charged liquid produces a dissipation of the charge, the authors examined the dissipation of a charge from a zinc plate, with or without water, when a current of dry or saturated air was passed over it. When the plate was filled with water, and the dry air produced strong evaporation, the rate of dissipation was 20 per cent. greater than when the saturated air passed over the plate and no evaporation took place. But the obvious conclusion that evaporation increases the rate of dissipation is contradicted by the fact that the same difference is found when the zinc plate contains no water at all. In fact, when the air is kept dry, an addition of water to the plate reduces, if anything, the rate of dissipation. The authors conclude, therefore, that the evaporating water does not take any of the charge away with it. This is confirmed by another experiment, in which saturated air was passed over a mixture of ether and water, and no dissipation took place in spite of the evaporation. Moist air acts as a perfect insulator, while dry air is a conductor, probably owing to a state of ionisation. The absence of loss by evaporation confirms the conclusions of Schwalbe, and controverts those of Pellat. E. E. F.

2208. *Kathode Ray Colouration of Fluorspar.* **W. B. v. Czudnochowski.** (Phys. Zeitschr. 1. p. 387, June 9, 1900.)—White fluorspar becomes dark violet and nearly black when exposed to kathode rays for any length of time. By reflected light the surface colour is a kind of bronze. The colouring is confined to the surface, and has no effect upon the colour or intensity of the blue fluorescence of the mineral under the influence of kathode rays. E. E. F.

2209. *Theory of Coherer.* **K. E. Guthe** and **A. Trowbridge.** (Phys. Rev. 11. pp. 22–39, July, 1900.)—To investigate the reason of the so-called coherer action a number of experiments were made on ball coherers. The lowering of the resistance of the coherer was produced by the closing of a circuit which consisted of a high E.M.F., which could be varied at will, a variable resistance, and the coherer, all in series. The resistance of the coherer was measured by observing simultaneously the current through, and the potential difference at, the terminals of the coherer. Balls of steel, lead, phosphor bronze, and copper-plated steel were used, and of diameter from 3 to 10 mm. Curves are then plotted with currents as abscissæ, and for the ordinates the corresponding values of potential difference at the coherer terminals. Almost all the resulting curves are expressible by an equation of the form—

$$p = P(1 - e^{-ki}),$$

where p is the potential difference of the coherer when the current through it is i, P and k are constants. It is thus seen that with increasing values of the current i, the potential difference p asymptotes to a limiting value P. The conclusion is drawn that the high original resistance of the coherer may be attributed to a film on the surface of the metallic particles, this film being possibly of condensed water vapour, through which electrolytic action occurs.

E. H. B.

2210. *Mechanical Oscillations of Electrically Luminous Wires.* **O. Viol.** (Phys. Zeitschr. 1. pp. 465–466, July 28, 1900.)—With reference to T. Tommasina's paper on photochemical effects produced by wires carrying electric waves [see Abstract No. 1675 (1900)], the author states that he has observed and recorded by means of a photographic camera luminous waves proceeding from a stretched insulated wire connected to a spark-gap. In the figure, L is the part of the wire which is stretched and insulated. When discharges pass across the gap F, mechanical oscillations are produced along L, which divides itself into bright and dark portions, giving the appearance of a luminous wave. The photographic effect of the luminous portions is weak,

but gives satisfactory negatives if the time of exposure is sufficiently prolonged. At first it appears as if the effects were due to electric waves (see W. Coolidge, Wied. Ann. 67, 578, 1899); but the phenomenon is independent of the length of the wire, nor is it noticeably affected by increasing the capacity. The appearance of the waves is determined by the spark-gap. If this is zero, *i.e.*, if the two balls are in contact (the conductor being negatively charged), then the wire is uniformly covered with luminous points. When the balls are moved apart so that sparks pass, luminous waves are seen: the number of these can be varied by varying the length of the spark-gap, and is inversely proportional to it. The pitch of the note heard along the wire is also inversely proportional to the length of the gap.

D. E. J.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

2211. *Hall Effect in Gases.* **E. Marx.** (Ann. d. Physik, 2. 4. pp. 798–834, Aug., 1900.)—According to the modern ionic theory, the Hall effect may be calculated from the difference between the positive and negative ionic velocities, and such a calculation, carried out in the case of electrolytes, indicates that no appreciable effect can be expected in them. In gases the electromagnetic transverse and longitudinal effects are very appreciable, but no quantitative results can be as yet obtained owing to the many complications which arise. One case of gaseous conduction, that of flame gases, is, however, sufficiently simple and well known to yield results of theoretical importance. In flame gases the transport of electricity is carried out by electrolytically dissociated ions, whose velocity is about a million times greater than in electrolytes, and shows a considerable difference in the positive and negative ions. The author has, therefore, studied this case experimentally, and has succeeded in finding a Hall effect which is distinctly appreciable, though necessarily small. He used a flat Bunsen flame, into which a fine spray of the solution of some alkaline salt was blown. He found that as the

atomic weight of the metallic base of the salt increased, so did the velocity of the ions, and the cæsium ions had therefore the greatest velocity. The Hall effect in electrolytes will probably remain too small for measurement.
E. E. F.

2212. *Measurement of Electric Absorption and Hysteresis.* **L. M. Potts.** (Amer. Journ. Sci. 10. pp. 91–114, Aug., 1900.)—This paper describes experiments made with a view to test the applicability of Rowland's methods of measurement by alternating currents [see Abstracts Nos. 144 (1898) and 1724 (1899)] to the determination of electric absorption in condensers, hysteresis, and other quantities occasioning loss of energy. Rowland's method is to join up a dynamometer with a Wheatstone bridge, the fixed coil in the galvanometer circuit and the moving coil in the arm containing the condenser whose absorption is to be measured. When the resistances of the bridge are adjusted so that the phase difference in the two coils of the dynamometer is 90°, there is no deflection.

A condenser possessing electric absorption is treated as a capacity in series with a resistance, and this apparent resistance is measured on a Wheatstone bridge by Rowland's method. Full details of the experiments are given. The apparent resistance is independent of the current, but increases rapidly with the temperature. The capacity of a condenser may be compared with a self-induction standard to 1 part in 1,000, after applying a correction for the absorption measured as indicated.

If a coil be substituted for the condenser, the hysteresis loss in its iron core may be measured by the same method ; only a very small quantity of iron is necessary.

A short circuit may be detected in one of two similar coils by approaching them successively to a coil in the bridge-arm, and comparing the apparent increase of resistance occasioned by their presence. G. H. B.

2213. *Dielectric Hysteresis.* **F. Beaulard.** (Journ. de Physique, 9. pp. 422–437, Aug., 1900.)—To decide between the rival hypotheses of viscosity and dielectric hysteresis, framed to account for the dissipation of energy observed in dielectrics subjected to changing fields, the author employs the method of Porter and Morris (see Electrician, April 12, 1895) and exposes various dielectrics to cyclic variations of different frequencies. Paraffin condensers show little or no loss of energy, and mica condensers very little.. Condensers of "dielectrine" show hysteresis areas bordered by straight lines when subjected to four different potentials in rotation. It is found that the energy dissipated varies with the rate of variation of the cycle, and tends to disappear when the rate decreases indefinitely. The apparent hysteresis is, therefore, a phenomenon of viscosity, best explained on Pellat's assumption of a progressive polarisation having a lag with respect to the polarising force [see also Abstract No. 1678 (1900)]. E. E. F.

2214. *Resistance of Thin Metallic Films.* **A. C. Longden.** (Amer. Journ. Sci. 9. pp. 407–409, June, 1900. See also Phys. Rev. 11. pp. 40–55, July, and 84–94, Aug., 1900.)—A study of the electrical resistance of thin films of metals deposited upon glass by kathode discharge in exhausted tubes, as described by A. W. Wright (Amer. Journ. Sci. 13. pp. 49–55, and 14. pp. 169–178). The films have enormously high electrical resistance—very much higher, as compared with thicker films of the same kind, than their thickness would seem to indicate. All very thin films have negative temperature-coefficients, and

films within a certain range of thickness have zero or negligible temperature-coefficients. After suitable artificial ageing and subsequent protection from the atmosphere, thin films may be regarded as perfectly trustworthy standards of resistance; the artificial ageing process must, however, be thorough. Contact with the terminal wires is made by depositing very thick films of negligible resistance on the ends of the thin films. The joints between the wires and the thick films are then secured by electro-deposition of copper and silver upon them. The resistances may be anything from a few ohms to several megohms. They can be made of pure metals and are thus free from the danger of disintegration common to alloys: they have the advantages of high resistance and low temperature coefficients which alloys possess. D. E. J.

2215. *Thermo-electric Currents.* **H. Egg-Sieberg.** (Elektrotechn. Zeitschr. 21. pp. 619–621, July 26, 1900.)—The author describes his repetitions of the early experiments of Le Roux, Ritter, and others on the phenomena of thermo-electricity, which lead him to suggest a slight modification in the statement of the hypothesis of F. Kohlrausch as to the origin of thermo-electric currents. This hypothesis he would express thus: In an unequally heated conductor electromotive forces prevail whose direction and magnitude depend on the nature of the conductor and on the existing temperature gradients. It is suggested that the earth's magnetism may be due to earth currents which have a thermo-electric origin. J. J. S.

2216. *Effects of Twist on the Thermo-electric Qualities of Iron.* **K. Tsuruta.** (Phil. Mag. 50. pp. 223–231, Aug., 1900.)—A description is given of some incomplete experiments carried out by the author in 1895 which indicate: (1) That in soft iron of certain kinds there exists the phenomenon of thermo-electric hysteresis with respect to twist; (2) that, other things being equal, the hysteresis is reversed at a certain twist; (3) that mechanical agitation has its own effects, which are reversed as the hysteresis is reversed. J. J. S.

2217. *Thermo-electric Power of Steels.* **G. Belloc.** (Comptes Rendus, 131. pp. 336–337, July 30, 1900.)—Curves of thermo-electric power between the temperatures 15° and 1,200° for three specimens, A, B, and C, are found to be similar in shape.

		Per cent. Carbon.
A	Soft iron	traces
B	Soft steel	0·30
C	Hard steel	1·25

The couples were formed between platinum and the respective specimens and tested in vacuo in an electric furnace, a third, a platinum rhodium wire, being present to give the temperature.

Temperature.		100°	470°	650°	770°	800°	860°	900°	940°	1,100°
dE/dt in microvolts.	A	20	9·9	13·6	18	18·8	19·2	15	11·2	15
	B	18	9·8	14	18·4	17·6	11	9·6	10·6	15·8
	C	16·5	10	14·4	7·6	7	9	11	12·4	17

The E.M.F. is smaller during cooling than during heating, especially between the maximum operating temperature and the temperature giving the maximum of the curve. Certain experiments show that viscosity and hysteresis play a *rôle* at high temperatures. G. E. A.

2218. *Electrolytic Interrupters.* **B. F. Bailey.** (Elect. World and Engineer, 36. pp. 207–210, Aug. 11, 1900.)—In the Caldwell interrupter the

action is symmetrical on both sides of the hole in the glass partition, and therefore the action on each half of the alternate-current wave is the same, both being interrupted. The time of complete interruption seldom lasts longer than $\frac{1}{5000}$ of a second. It is quite possible to obtain two breaks in a single wave by means of the Caldwell interrupter. In the accompanying diagram (Fig. 1) curve A represents the double interruption in a circuit in which the current was about 2 amperes at 150 volts and 40 cycles per second. The inductance of the circuit was 0·062 henrys. Curve B was taken under the same conditions, except that the inductance was reduced to $\frac{1}{38}$ of its former

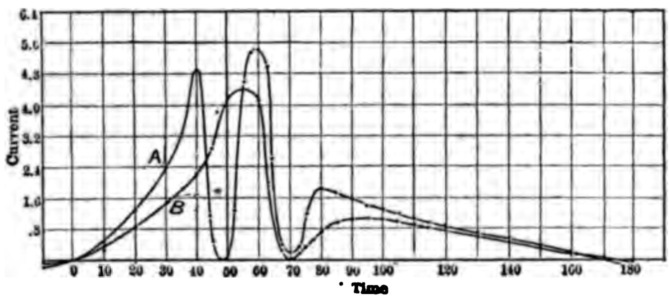


FIG. I.

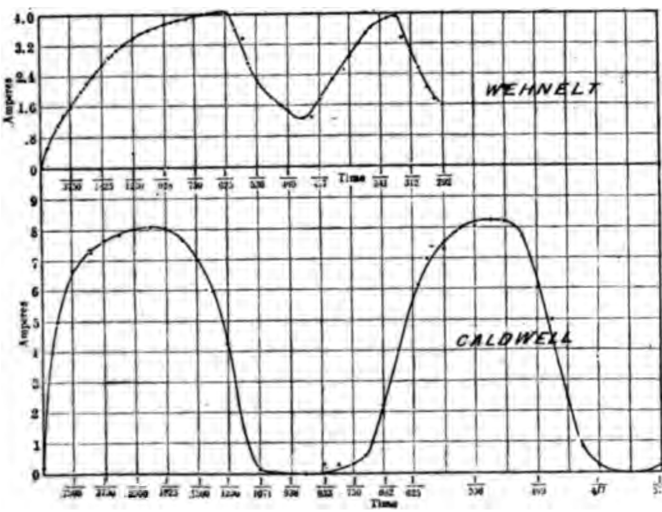


FIG. 2.

value. The author has also devised a contact-maker for direct-current work which enables him to explain the apparently large consumption of power by the electrolytic interrupter as due to the fact that the E.M.F. and the current do not coincide in phase. Fig. 2 gives the first two waves of a Wehnelt and a Caldwell interrupter respectively. In the former, the interruption is not complete. In the latter, the first wave rises more steeply than the second, owing to the fact that the hole is full of liquid and the first part of the curve is that of the rise of the current in an inductive circuit. E. E. W.

2219. *Wehnell Interrupters in Parallel.* **E. Ruhmer.** (Elektrotechn. Zeitschr. 21. pp. 699–700, Aug. 16, 1900.)—When two Wehnelt interrupters are connected in parallel their interruptions are synchronous, though they may have naturally very different frequencies. Two or more Wehnelt or Caldwell-Simon interrupters mounted in parallel are equivalent to a single interrupter having a platinum surface or perforation area equal to the sum of the surfaces or areas taken singly. Out of two interrupters studied, one had an effective anode surface of 9·18 sq. mm., and the other 18·35 sq. mm. The natural frequencies were 1,460 and 1,170 interruptions per second, with 12 and 22·5 amperes respectively. The combined interrupter had a frequency of 790 per second, and the current intensities were then 10·25 and 20·5 amperes respectively. If a separate inductance is attached to each interrupter, they no longer work in synchronism, and the pure note becomes a combination of notes, with a resulting summation tone. If the two interrupters are to have equal frequencies without being synchronous, care must be taken to make the inductances inversely proportional to the surfaces of the active electrodes.

E. E. F.

2220. *E.M.F. of Cadmium Cell.* **E. Cohen.** (Ann. d. Physik, 2. 4. pp. 863–864, Aug., 1900.)—The table of E.M.F.'s of the Weston cadmium cell given by Marek for temperatures ranging from 5° to 26° [see Abstract No. 1091 (1900)] may lead to grave errors below a temperature of 23°, since the cell is completely metastable below that point. The table of E.M.F.'s therefore only retains its value between the temperatures of 23° and 26° C.

E. E. F.

2221. *E.M.F. of Cadmium Cells.* **W. Jaeger** and **S. Lindeck.** (Ann. d. Physik, 3. 2. pp. 366–368, Oct., 1900.)—The authors protest against Cohen's premature announcement [see preceding Abstract] of alleged faults in the Weston cell as likely to cause confusion. The Reichsanstalt standard Weston cell keeps its E.M.F. constant within 0·01 per cent., and 80 per cent. of all Weston cells examined do not vary by more than 0·02 per cent. from their mean value. To avoid all chances of error, it is sufficient to employ the Weston cell always at ordinary temperatures or above, and to use a somewhat more dilute cadmium amalgam than that of 14·3 per cent. as hitherto prescribed.

E. E. F.

2222. *Resistance of Cadmium Cell.* **I. Klemenčič.** (Ann. d. Physik, 2. 4. pp. 848–853, Aug., 1900.)—Some figures are given for the resistances of two Weston cells at various epochs and temperatures. They show that in the course of eighteen months the resistance increased somewhat, but that the increase is much smaller than it is in cadmium cells with extra crystals of cadmium sulphate. The resistance at a given temperature is not affected by intermediate heating. The internal resistance is of great importance for practical use. Its constancy in the Weston cell is largely due to the efficient sealing of the cell.

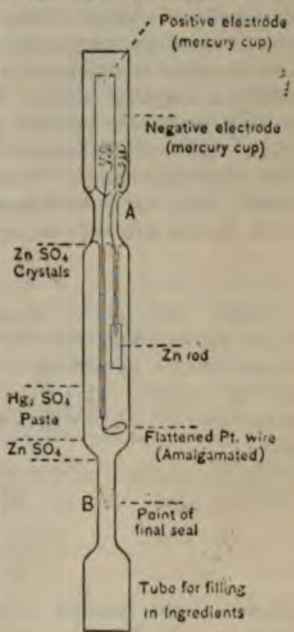
E. E. F.

2223. *An Adjustable Condenser.* **L. J. Briggs.** (Phys. Rev. 11. pp. 14–21, July, 1900.)—This paper describes a condenser whose capacity is capable of continuous adjustment within limits. It consists of a stack of conducting and insulating plates placed alternately. The conducting plates are formed of thin spring brass sheets slightly curved: the insulating plates each consist of two sheets of mica. These plates are arranged in an insulated frame with a

compression screw at the top. As this is screwed up the brass plates are flattened and the dielectric space diminishes, thus increasing the capacity. On releasing the screw the brass plates recover their original curvature.

E. C. R.

2224. *Hermetically Sealed Clark Cell.* **H. T. Barnes.** (Phys. Rev. 10. pp. 268–276, May–June, 1900.)—This cell is a "crystal" cell, so constructed that the glass containing-tube may be sealed off in the blowpipe. The arrangement will be readily understood by referring to the figure. A platinum wire, which is flattened and amalgamated at one end, is used instead of mercury. It is sealed into a glass tube which is large enough to form a mercury cup at one end, but is a capillary along that part which projects into the interior of the cell. The zinc rod is cast round a platinum wire, and also round the end of the capillary glass tube through which this wire passes. These two capillary tubes are fused into the neck A of the main tube, connection being made with the platinum terminals when required by means of mercury. The zinc is amalgamated by dipping into mercury, on the top of which is a layer of dilute sulphuric acid. In filling the cell, moist zinc sulphate crystals are pushed through the neck B until the zinc rod is covered. A layer of mercurous sulphate paste is then inserted, and finally a thin layer of zinc sulphate crystals in order to protect the paste from the heat when the neck B is sealed off.



The change of E.M.F. with temperature was found to be expressed in millivolts by the following equation :—

$$E_t = E_{15} - 1{\cdot}200\,(t-15) - 0{\cdot}0062\,(t-15)^2.$$

The cells appear to be satisfactory as regards permanence and reproducibility. The author recommends the short circuiting of new cells in order to bring them into a steady condition.

W. R. C.

2225. *The "Column" Measuring Instruments.* (Elect. World and Engineer, 36. pp. 222–225, Aug. 11, 1900.)—Air is supplied at a pressure of about $1\frac{3}{4}$ lbs. per square inch to a chamber partially filled with a non-volatile oil, into which dips a vertical tube graduated with the scale of the instrument. Before reaching the chamber the air passes through a series of filter-paper diaphragms and a passage from which a valve opens to the atmosphere. The pressure on this valve, and consequently the height to which the oil rises in the tube, is regulated by a coil carrying the current to be measured and capable of motion along one leg of a horseshoe permanent magnet. As the motion of this coil is very small (less than $\frac{1}{100}$ inch) the pressure it exerts on the valve is exactly proportional to the current through it.

Several indicating tubes can be attached by tubes to the chamber of one instrument. The air is supplied either by a small pump run by a motor or by a water injector.

The instrument can be made to record, by attaching a pen to a float on the surface of the oil column. The makers are The Whitney Electrical Instrument Co. G. H. B.

2226. *Needle for Exploring Electrostatic Fields.* **F. J. Rogers.** (Phys. Rev. 11. pp. 56–58, July, 1900.)—In order to render evident to a class the existence and characteristics of an electrostatic field the author has devised two forms of an "electrostatic needle." These perform for the electrostatic field the same functions as are performed for the magnetic field by iron filings and by a magnetic needle. The form analogous to an iron filing consists of an aluminium wire pierced at the centre, and provided with pith balls at its ends. This needle is mounted on a horizontal axis consisting of a pin stuck into an ebonite handle. The second form of needle, analogous to a magnetic needle, has a rod of hard rubber in place of the aluminium wire. To prepare it for use the pith balls are oppositely charged from an electrical machine. E. H. B.

2227. *Magnetometer Constant.* **C. Chistoni.** (Acad. Sci. Torino, Atti, 35. 8*a*. pp. 395–409, 1900.)—The author determines the constant of a unifilar magnetometer by placing a deflecting magnet at two distances, R_1 and R_2, from the needle. This gives the deviations ϕ_1 and ϕ_2, while the temperatures of the needle and of the deflecting magnet are τ_1 and τ_2 respectively. Then put—

$$\frac{2(1-a\tau_1)(1-h\,H\sin\phi_1)}{R_1^3(1+3\beta\tau_1)\sin\phi_1}=A_1$$

$$\frac{2(1-a\tau_2)(1-h\,H\sin\phi_2)}{R_2^3(1+3\beta\tau_2)\sin\phi_2}=A_2$$

Where a is the thermal coefficient of the deflecting magnet, h its induction coefficient, H the earth's horizontal force, and β the coefficient of linear expansion of the scale. Then the magnetometer constant p is given by—

$$p=\frac{(A_1/A_2-1)\,R_1^2(1+2\beta\tau_1)}{\dfrac{R_1^2(1+\beta\tau_1)}{R_2^2(1+\beta\tau_2)}-\dfrac{A_1}{A_2}} \qquad (1)$$

From this exact formula the following approximate formula may be deduced—

$$\log p=\log C+\log\left[(\log\sin\phi_1-\log\sin\phi_2)+\log C\right] \qquad (2)$$

where—

$$C=-\frac{R_1^2}{(R_1^2/R_2^2-1)\log e}$$

and—

$$\log C=[\log 1+a(\tau_1-\tau_2)]+\log[1+hH(\sin\phi_1-\sin\phi_2)]+\log\frac{R_1^3}{R_2^3}$$

The author shows, in reply to Palazzo's criticism, that formula (1) is rigorously correct, and that formula (2) can be used in most cases, though care must be taken against neglecting the term involving h. E. E. F.

2228. *Electrical Measuring-Instruments.* **J. F. Stevens.** (Frank. Inst., Journ. 150. pp. 44–62, July, 1900.)—In this paper the author discusses the advantages and disadvantages of the various forms of measuring instruments

used on electric lighting circuits. Some figures are given showing that h wire shunt ammeters are not satisfactory, one for 1,000 amperes requiri 8 H.P. to operate it, when tested. A novel form of hot-wire instrument also described, consisting of an aneroid barometer with a resistance wire the expanding chamber. These instruments can be made to be accurate, b they necessarily act slowly. C. K.

ALTERNATING CURRENTS AND MAGNETISM.

2229. *Current Curves by Lichtenberg Figures.* **W. König.** (Ann. Physik, 2. 4. pp. 860–862, Aug., 1900.)—In comparing his own method recording potentials with Grützner's electrolytic current records [s Abstract No. 1478 (1900)], the author admits that both are of limited ran of application. The electrolytic method is unsuitable for rapid electr oscillations. E. E.

2230. *Resonance in Transmission Work.* **D. H. Fry.** (Journal of Ele tricity, S.F. 9. pp. 61–62, April, 1900.)—A simple, practical method is given analysing alternating E.M.F. waves into their constituent harmonics. T special form of Fourier's theorem for an E.M.F. wave is—

$$e = a_1 \sin\phi + a_3 \sin 3\phi + \ldots + a_{2n-1}\sin(2n-1)\phi + \ldots$$
$$+ b_1\cos\phi + b_3\cos 3\phi + \ldots + b_{2n-1}\cos(2n-1)\phi + \ldots$$

To determine a_{2n-1} and b_{2n-1} from a drawing of the positive half of t E.M.F. wave, divide the base of the curve into $4n-2$ equal parts and dra the $4n-3$ ordinates, $e_1, e_2, \ldots e_{4n-3}$.

Then approximately—

$$a_{2n-1} = \frac{1}{2n-1}(e_1 - e_3 + e_5 - \ldots + e_{4n-3}),$$

and—

$$b_{2n-1} = \frac{1}{2n-1}(-e_2 + e_4 - \ldots + e_{4n-4}).$$

Hence the $(2n-1)$th harmonic is $A_{2n-1}\sin[(2n-1)\phi + \alpha_{2n-1}]$, where—

$$A_{2n-1} = \sqrt{a^2_{2n-1} + b^2_{2n-1}},$$

and—

$$\tan\alpha_{2n-1} = \frac{b_{2n-1}}{a_{2n-1}}.$$

An example is worked out showing that the method is a simple one a that it gives accurate results. Some remarks are made as to the effects harmonics in the polyphase working of transmission lines. A.

2231. *Permeability of Iron under the Influence of the Oscillating Discha from a Condenser.* **E. W. Marchant.** (Nature, 62. p. 413, Aug. 30, 190 —Photographs are given of sparks taken with the aid of a revolving mirr from a coil of five millihenrys self-induction and a Leyden jar of 0·06 micr farads, the difference of potential before discharge being 13·5 volts. T effect of the soft iron core upon the nature of the spark is well shown. T first half oscillation with the core in is seen to be nearly twice as long without it, and a series of oscillations follow it gradually increasing in leng

The increased length of the first spark is due of course to the increase

the self-induction of the coil by the introduction of the core, and the gradually increasing length of the sparks that follow is due to the increased permeability of the core as the intensity dies away. Over three hundred spark-photographs have been taken, and iron has been found to act in the same way under these oscillatory discharges as it does where steady currents are used to produce magnetising forces of the same intensity. In some experiments the magnetising current was 1,000 amperes, and this was obtained by using a large glass condenser, capacity 1·5 microfarads, formed of plates of glass 1·6 mms. thick, coated with shellac, the conducting surfaces being of tin-foil. The condenser was charged by a large Wimshurst machine of 160 plates and a full difference of potential of 20,000 volts. W. C. O.

2232. *Electromagnetic Rotations.* **W. König.** (Ann. d. Physik, 2. 4. pp. 854–860, Aug., 1900.)—The author replies to Lecher's criticism [see Abstract No. 94 (1900)], and maintains that the current explanation of Pohl's experiment is correct, unless it is assumed that the lines of force are rigidly attached to the magnet. E. E. F.

2233. *Magnetic Observations near Electric Tramways.* **T. Moureaux.** (Comptes Rendus, 131. pp. 337–340, July 30, 1900.)—In order to accommodate the instruments which record curves of magnetic variation in the Parc St. Maur Observatory, Paris, so that the disturbances proceeding from the electric tram service 3,200 metres distant may be rendered negligible, three modifications have been made on a declinometer and a bifilar. These are the use of square-ended, strongly magnetised bars, 5 cm. long, the addition of a special stirrup which increases the moment of inertia of the oscillating system by one-third, and the disposition of the magnet so that it oscillates just above a copper plate. The indications of a normal bifilar show that the changes made reduce the perturbations to one-tenth of their value. G. E. A.

2234. *Behaviour of Fluids in the Magnetic Field.* **G. Jäger.** (Akad. Wiss. Wien, Sitzb. 108. pp. 1499–1509, 1899.)—Duhem's formula is only applicable to dilute solutions which cannot be investigated experimentally, and an investigation is now given of the behaviour of a liquid in a ring-shaped vessel in one side of which the meniscus is in a magnetic field. No change in the capillarity-constant of a liquid could be observed in a powerful magnetic field; but when the liquid is a solution in a non-magnetic solvent it is shown that a change in the vapour-tension must occur, and that this can only be caused by a change in the concentration of the solution, and that a slight potential difference must occur, the value of which can be calculated. An experiment gave only indecisive results. T. M. L.

2235. *Magnetic Deposits formed in a Magnetic Field.* **C. Maurain.** (Comptes Rendus, 131. pp. 410–413, Aug. 13, 1900.)—On electrolysing a solution of ferrous sulphate in sodium pyrophosphate arranged inside a magnetising spiral, adherent brilliant deposits of iron are obtained, the magnetisation of which may be measured by means of a magnetometer. During the formation of a deposit in a field of constant strength by a constant electrolysing current, for the first few minutes there is no action on the magnetometer; but after this period the action increases very nearly proportionally with the time, so that the intensity of magnetisation is constant for the different layers of the deposit. Also by using fields of different

strengths it is found that the intensity of magnetisation acquired by a deposit increases with the strength of field in which it is obtained. If, after a deposit has been formed in a constant field, the latter be gradually decreased to zero, the action on the magnetometer shows only a very slight variation. When the strength of field is increased from the initial value H_0 the magnetisation of the deposit increases slowly if H_0 is large, but quickly if H_0 is small; if H_m is the maximum value reached by the strength of field, and the latter be then continuously decreased, the magnetisation decreases very slowly, even when the field becomes of negative sign. On reaching a value $-H_1$, arithmetically much greater than H_m, the magnetisation diminishes very rapidly to a value much greater than that obtained for the strength of field H_m unless the latter brought the iron near to saturation. These variations are shown by the following table, in which the values of H represent the successive values given to the strength of field, and I the corresponding deflections of the magnetometer.

H	+2·65	+14·8	−18·5	−23·3	+18	+23·2	−19	−23·1	0
I	+93·7	+129·4	+104·1	−180·2	−160	+174	+162·6	−183·6	−178·1

The coercive force is therefore enormous, and the reversal of the magnetisation is effected suddenly for a very small variation in the field. T. H. P.

2236. *Effects of Temperature on the Magnetic Properties of Iron and Alloys of Iron.* **R. L. Wills.** (Phil. Mag. 50. pp. 1–37, July, 1900.)—Ewing divides the magnetising process of magnetic metals into three stages. During the first stage the permeability is small and there is practically no retentiveness. In the second stage the curve of magnetisation rises rapidly and the permeability is high. In the third stage the permeability decreases and the specimen approaches saturation. The effect of heat is to make the transition from one stage to another occur at lower values of the magnetising force, but the temperature effect has previously only been studied for magnetising forces so large that the heat applied has brought on the second stage of the magnetising process. In the present investigation the author has studied the influence of temperature on the permeability for small values of the magnetising force. The metals used were iron and alloys of iron with tungsten, aluminium, and nickel, and a steel containing chromium and manganese which was non-magnetic in the unannealed state, but became magnetic on being annealed.

The metals were obtained in the form of rings which were wound with the magnetising coils, the induction being measured ballistically on reversing the magnetising current. The magnetising force was kept constant and the temperature gradually raised, the induction being measured at certain temperature intervals until the non-magnetic state was reached. The permeability-temperature curves thus obtained for different values of the magnetising force are plotted in the paper, as are also μ-H curves for constant temperatures, up to about 800° C., obtained directly by experiment, the temperature being kept constant while H was varied.

The results for the different metals are best studied from the curves.

J. B. H.

2237. *Magnetic Declination at Greenwich.* **A. Schuster.** (Cambridge Phil. Soc., Trans. 18. pp. 108–135, April, 1900.)—The author gives a method of analysing complex variation curves, by means of Fourier's series, which is

capable of discriminating between accidental and truly periodic variations, If $f(t)$ is any function of t, and the quantity R is determined by the equations—

$$\tfrac{1}{2}n\mathrm{TA} = \int_{\tau}^{\tau+n\tau} f(t)\cos\kappa t\,dt$$

$$\tfrac{1}{2}n\,\mathrm{TB} = \int_{\tau}^{\tau+n\tau} f(t)\sin\kappa t\,dt$$

$$\mathrm{R}^2 = \mathrm{A}^2 + \mathrm{B}^2$$

where $\kappa = 2\pi/\mathrm{T}$, n is an integer, T represents a certain interval, and τ a time which can be varied, then a change in τ with constant n and T will cause R to fluctuate round some mean value. Let S^2 be the mean value of R^2 which will in general depend upon T, with T as abscissa and S^2 as ordinate, draw a curve, which may be called the *periodograph*. Then the author defines the *periodogram* as the surface included between this curve and the axis of T. The periodograph corresponds exactly with the curve which represents the distribution of energy in the spectrum. The author discusses several special cases, in one of which the function $f(t)$ is formed by the superposition of one or more simple periodicities on an irregular curve varying within certain limits. This is the case of barometric, thermometric, and magnetic changes. When the periodicities are real, the value of the ordinates of the periodogram is independent of the range of time over which the integration is performed, whereas it varies inversely with the time when they are accidental.

This method was applied to the Greenwich declination records of the twenty-five years (1870–1895). It was found that the causes which produce the variations of declination are, on the whole, persistent in character, so that the variations of short periods have on the average a much smaller amplitude than those of longer periods. When the square of the amplitude (the "intensity") of a disturbance becomes seven times its expectancy or probable value, the probability of a real effect is 1,000 to 1. Applying this to the alleged 27-day period, it appears that there is no period between 25·5 and 27·5 days whose amplitude exceeds 0·077 minute of arc. But within that limit, the probability of a synodic lunar period of amplitude 0·054 minute is established with a probability amounting to 2,000 to 1. E. E. F.

2238. *Magnetic Disturbances in the Island of Skye.* **A. Harker.** (Cambridge Phil. Soc., Proc. 10. pp. 268–278, May 7, 1900.)—The disturbances described by the author are found in the Cuillin Hills, composed mainly of gabbro, which occupy the central part of the island, and on the moorland plateaux, consisting of basalt, which extend thence northward and westward, covering about half the area of Skye. On any salient point, either of the gabbro mountains or the basalt plateaux, the rocks are permanently magnetised, and very often to such an extent that, by moving the compass about, the needle may be made to point in any direction. The disturbance affects dip as well as declination, so that, with the dial held horizontally, the needle will often jam against the card. When a rock-face forming part of such an eminence is tested more closely with the compass, it is found that certain points of the rock behave as north poles and others as south poles, such poles being irregularly distributed at intervals varying from a few inches to a few feet.

These phenomena are not confined to high mountain-summits, but are exhibited equally by insignificant knolls on the moorland plateaux, provided

they form the highest ground in their immediate neighbourhood. The localisation of these intense magnetic disturbances in such situations seems to point very decidedly to atmospheric electricity as the cause of the magnetisation of these salient points of rock. It is not necessary to suppose that the exposed points have been struck by lightning. Indeed, the remarkable rarity of thunderstorms in Skye rather suggests that the summits act to some extent as lightning-conductors. It is easy to show too that no great lapse of time is required for rocks so exposed to become magnetised. The stones composing the cairns erected by the Triangulation Survey are invariably highly magnetic, while the loose stones lying about the base of the cairn are much less so. This is true even of small cairns erected by climbers within a few years past. E. E. F.

MEDICAL ELECTRICITY.

2239. *Oscillating Rheostat for Producing Current Waves.* **S. Leduc.** (Archives d'Él. Médicale, 8. pp. 300–306, July, 1900.)—A brass wire in the form of a horseshoe is varnished with collodion on one side, and the extremity of the varnished end cut to give a conducting surface. The end of the unvarnished side is attached to the pendulum of a metronome interrupter, the other end being balanced with a lead wire. The varnished end is plunged into a glass, at the bottom of which is placed some mercury. The pendulum of the metronome is connected with one of the poles of a generator, the other pole being connected with the mercury in the glass. In the circuit thus formed is placed a physiological subject. On the mercury a badly conducting liquid is placed, such as filtered water, which closes the circuit. The metronome being started, the brass wire is successively raised and lowered so that the unvarnished end approaches the mercury without touching it and recedes without leaving the water. The intensity of the current is thus periodically varied, and the variation is measured by the variation of muscular contractions. W. G. R.

2240. *Influence of Static Electricity on the Healthy Organism.* **P. Yvon.** (Archives d'Él. Médicale, 8. pp. 256–276, June, 1900.)—The object of the investigation was to determine the action of the "static bath" on the elimination of urea and of phosphoric acid, as well as its action upon respiration, circulation, and the temperature of the body. The writer experimented upon himself, one pole of the machine being to earth the other attached to the insulating stool upon which he sat. The duration of each bath was two hours. Neither the "souffle," "friction," nor "sparks" were used. A Wimshurst machine without sectors was employed, giving, between the knobs, sparks of about 9 centimetres in length, that is to say, with a potential of about 115,800 volts, according to Mascart's table. The conclusion from the first series of experiments was that the action of the static bath (and of the ozone produced) upon temperature, pulse, and respiration was practically nil. The effect upon the output of urea and phosphoric acid was not sufficiently marked to draw any conclusion whatever. A second series of experiments, undertaken with more elaborate precautions against possible errors, fully confirmed the above results; the writer concludes that the physiological action of static electricity upon the healthy organism is very slight, if, indeed, such an influence exists at all under the conditions in which the above experiments were carried out.

The opinion of Duchenne (of Boulogne), who wrote in 1855 that static electricity produced no physiological effect, is fully confirmed by the above experiments. (Elaborate tables accompany the paper.) W. S. H.

2241. *Action of High-Frequency Currents upon the Activity of the Exchanges between the Blood and the Tissues.* **Tripet.** (Comptes Rendus, 130. pp. 1785–1787, June 25, 1900.)—D'Arsonval having shown the powerful influence of high-frequency currents in modifying nutrition, and Apostoli and Berlioz having proved their effect in increasing the output of urea, the present writer undertook a series of experiments to show the effect of such currents upon the activity of the reduction of oxyhæmoglobine, *i.e.*, upon the activity of the exchanges between the blood and the tissues. For two years he followed a series of cases in Apostoli's clinic before, during, and after their treatment by currents of high frequency, and fifty-three observations are tabulated for presentation to the Academy. The results of this treatment may be summed up as follows: (1) In thirty-seven cases the activity of the reduction of oxyhæmoglobine was increased—a fact which especially appeared in cases of perverted nutrition (rheumatism, uterine fibroids, &c.). (2) In ten cases where, before the treatment, the reduction was excessive it afterwards became normal. (3) In only six cases in which the disease did not prove amenable to treatment the activity of the reduction of oxyhæmoglobine continued to decrease.

We may conclude, therefore, that (*a*) In diseases of nutrition treatment by high-frequency currents has a regulating effect on the activity of the reduction of oxyhæmoglobine. (*b*) In cases where this activity is below the normal it becomes increased. (*c*) In cases where this activity is exaggerated—for example, in diabetes—the treatment diminishes it. (*d*) It is to be remarked that there is almost always a simultaneous increase in the percentage of oxyhæmoglobine and its activity of reduction. W. S. H.

2242. *Hertzian Franklinisation.* **H. Bordier.** (Archives d'Él. Médicale, 8. pp. 241–255, June, 1900.)—The writer considers that the appellation "Static Induced," hitherto given to the currents of Morton, is an unsatisfactory term, and proposes instead the term *Hertzian Franklinisation.* In electro-therapeutics Franklinisation is the name usually given abroad to treatment by the static machine. It embodies three chief applications: the static bath, sparks, and the electric breeze. To justify the qualifying term, *Hertzian*, the author enters into a lengthy explanation of Hertzian phenomena. He then considers the conditions of the Morton method (Static Induced). In this arrangement two Leyden jars are attached to the collectors of the static machine by their internal armatures; of the external armatures one is put to earth, the other is attached to the exciter for application to the body. The terminals of the machine are then approximated, so that sparks of the desired length pass between the knobs when the machine is in action.

To examine the electrical phenomena which occur under such conditions, he deals in detail with various modifications of Morton's arrangement, and considers that, the production of Hertzian vibrations and a Hertzian field being duly proved, the new name which he suggests, viz., Hertzian Franklinisation, is fully justified. W. S. H.

2243. *Alternating Current Transformer for Medical and Industrial Use.* **P. Renaud.** (Électricien, 19. pp. 353–354, June 9, 1900.)—This apparatus, designed by Gaiffe, of Paris, is intended chiefly for the use of medical men who have an alternate current lighting-circuit. It is composed of a primary and two secondary circuits, the latter being so arranged that any number of turns can be used according to the purpose in hand. The originality in the apparatus consists in the fact that the two secondaries can be used at the

same time and for different purposes. It can either be used for cautery, light, or direct application to the patient. The different values of the current rendered are as follows :—

Circuit	1·0 to 8	volts,	0 to 30	amperes.
„	2·0 to 16	„	0 to 2	„
„	12·0 to 24	„	0 to 2	„

For medical use the first circuit is employed for cauteries which take 2 to 3 volts and 10 to 30 amperes. The second circuit would supply exploring lamps which take 2 to 10 volts and 0·5 to 1·5 amperes.

For alternating currents to be applied directly to the body the maximum required would be for the electric bath. For this 20 volts are sufficient to obtain the 100 or 125 milliamperes, which is the strongest current that can be borne. W. S. H.

REFERENCES.

2244. *A Percentage Bridge.* **H. C. Parker.** (Amer. Inst. Elect. Engin., Trans. 17. pp. 229–232, April, 1900.)—A method is described of using an ordinary wire bridge to compare two resistances which are nearly equal to one another. Two "percentage" coils (methods of calculating which are given) are placed at the ends of the wire and the readings on the wire are then in percentages which greatly simplifies the calculation. A. R.

2245. *De-cohering Action of Current.* **S. Marcucci.** (N. Cimento, 11. pp. 173–177, March, 1900.)—The author describes in detail several cases in which the conductivity of a coherer is annulled by sending a feeble current through it. E. E. F.

2246. *Electric Distribution along a Hertz Resonator.* **A. Turpain.** (Comptes Rendus, 130. pp. 1609–1611, June 11, 1900.)—A study of the oscillatory current in a circular Hertz resonator by a method which consists in enclosing the resonator in a glass tube, inside which the air is suitably rarefied. D. E. J.

2247. *Kathode Rays.* **E. Merritt.** (Science, 12. pp. 41–48, July 13 ; and pp. 98–104, July 20, 1900. Address of the Chairman of Section B of the American Association.)—Historical.

2248. *Theory of Unipolar Gas-Discharges.* **E. v. Schweidler.** (Akad. Wiss. Wien, Sitzb. 108. pp. 899–904, 1899.)—In connection with his investigations on photo-electric phenomena [see Abstract No. 141 (1900)] the author has endeavoured to deduce theoretically relations between the current, electromotive force, distance between electrodes, &c. The results of his calculations do not entirely agree with the experimental observations. D. E. J.

2249. *Distribution of Currents and E.M.F.'s in a Network of Conductors.* **L. Donati.** (Elettricità, Milan, 19. pp. 356–358, June 9, 1900. Read before the R. Accademia delle Scienze dell' Istituto di Bologna, Nov. 26, 1899, and Feb. 11, 1900.) —The author deduces formulæ connecting the values of the E.M.F.'s and currents in a network of wires and discusses some applications. G. H. B.

2250. *Dynamics of a System of Electrons.* **J. Larmor.** (Cambridge Phil. Soc., Trans. 18. pp. 380–407, April, 1900.)—A mathematical paper on the dynamics of a system of interacting electrons or ions, and on the influence of a magnetic field on optical phenomena. J. J. S.

2251. *Use of Chronograph in Electrical Measurements.* **W. Marek.** (Elektrotechn. Zeitschr. 21. pp. 641–643, Aug. 2, 1900.)—After a brief description of the chronograph, the author considers its use in the determination of the constants of supply meters, the frequency of alternate currents, and the period of oscillation of a galvanometer. A. H.

2252. *Residual Magnetism and Coercive Force.* **Colard.** (Soc. Belge Élect., Bull. 17. pp. 178–201, May, 1900.)—The author discusses the subject of magnetic circuits having a gap, and emphasises the demagnetising effect of the gap. W. H. E.

2253. *Mechanical Model Illustrating the Behaviour of Geissler Tubes.* **W. Kaufmann.** (Phys. Zeitschr. 1. pp. 59–60, 1899.)

2254. *Electric Discharge in Helium.* **W. Heuse.** (Deutsch. Phys. Gesell., Verh. 2. 2. pp. 16–18, 1900.)

2255. *Molecular Susceptibilities.* **H. du Bois** and **O. Liebknecht.** (Deutsch. Phys. Gesell., Verh. 2. 2. pp 19–21, 1900.)—A paper similar to that referred to in Abstract No. 1096 (1900). E. E. F

2256. *Measurements of Polarisation.* **F. Haber.** (Zeitschr. Elektrochem. 7. pp. 13–15, July 5, 1900.)—A description is given of a bridge consisting of a stretched platinum-iridium wire, about one metre long, with its connections, especially designed by H. Luggin for the measurement of differences of potential, such as those dealt with in experiments on polarisation. J. J. S

2257. *Accumulator Testing by Means of a Third Electrode.* **L. Jumau.** (Écl. Électr. 24. pp. 59–65, July 14, 1900.)—This paper contains a number of curves compiled from the author's own researches and those of Schoop, showing the variations on discharge and recharge of the E.M.F. and potential difference of both positive and negative electrodes relatively to a third electrode or test-plate. From these figures deductions are made as to which electrode is responsible for various features of the cell's behaviour. E. J. W.

2258. *Wehnelt Interrupter with Alternating Currents.* **B. F. Bailey.** (Elect. World and Engineer, 36. pp. 52–54, July 14, 1900.)—An account is given of various tests applied to circuits with alternating currents and containing a Wehnelt interrupter. Experiments were made with a small two-pole rotary transformer, changing from direct current at 220 volts to alternating current at 150 volts and 40 cycles per second. Curves of current and E.M.F. are given in the paper. J. J. S.

2259. *Electromagnetic Mechanism.* **R. A. Fessenden.** (Frank. Inst., Journ. 149. pp. 459–470, June ; 150. pp. 62–80, July ; and 106–133, Aug., 1900.)—The author considers certain points in the design of electromagnetic mechanism. The first portion of the paper is given to magnetic units and nomenclature, as adopted by the American Institute of Electrical Engineers, with the addition of such derivatives as weberivity, gilberivity, œrstedivity, and voltivity, all of which are duly defined. Examples are added, showing the application of these terms in the measurement of energy for magnetic and dielectric circuits. R. A.

2260. *Electric Conductivity of Oxides at High Temperature.* **J. Sohlman.** (Elektrotechn. Zeitschr. 21. pp. 675–676, Aug. 9, 1900.)—This paper contains a comparison of the conducting power of metallic oxides with the relative positions of the metals in the "periodic system." J. B. H.

2261. *Magnetometer.* **A. Cotton.** (Écl. Électr. 24. pp. 257–266, Aug. 18, 1900.) —An extended account of the instrument referred to in Abstract No. 1477 (1900).

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

2262. *Permeability of Fused Silica to Hydrogen.* **P. Villard.** (Comptes Rendus, 130. pp. 1752–1753, June 25, 1900.)—Fused silica is, like platinum, permeable to hydrogen, but to a less extent. The substance is heated to a red heat, about 1,000°, in a Bunsen burner. The best form to give it is that of an exhausted bulb, heated in a Bunsen flame. The pressure gradually rises within the bulb, and attains several centimetres in one day. The gas which has penetrated into the bulb may be made to leave it by surrounding the bulb with a platinum case, in which air circulates, and heating again. That hydrogen is the gas which penetrates the walls of the bulb may be proved by attaching a small platinum tube to it. The gas which penetrates into the bulb can then be pumped out through the platinum at a red heat. The permeability of the silica is much increased when the substance is heated until it begins to soften. The bulb may be made to produce a musical note by blowing a current of air through it and heating it to 1,500°. The hydrogen, in penetrating the wall of the tube, is burnt to water, and the rhythmic condensation of the latter produces the note. A similar note may be produced in a heated glass tube containing a drop of water. E. E. F.

2263. *Colloidal Solutions.* **G. Bruni** and **N. Pappadà.** (Accad. Lincei, Atti, 9. pp. 354–358, June 3, 1900.)—To decide the question as to whether collodial solutions really contain the colloid in a state of solution, and only differ from ordinary solutions in that the molecules are present in complex aggregates, or whether they must be regarded as containing the colloid suspended in the liquid in a very fine state of subdivision, the author makes the following experiments. Solutions of the following colloids—silicic acid, ferric hydroxide, chromic hydroxide, ferric ferrocyanide (Prussian blue), egg albumin, and gelatine—are submitted to dialysis for varying periods, in no case less than a fortnight, the external liquid being frequently changed, especially in the first few days. In no instance is it found that any of the colloid diffuses through the dialyser, and, further, the freezing-points of the colloidal solution and of the external liquid with which it is in equilibrium show only very small differences, which are within the limits of experimental error. On carrying out vapour tension experiments by a modification of Ostwald and Walker's method, in which a current of air is passed through a series of five flasks, the first three containing the colloidal solution and the others the corresponding external liquid of the dialysing apparatus, no appreciable variations of weight are found in the last four of the flasks. The bodies known as semi-colloids, *e.g.*, dextrin and molybdic acid, pass relatively readily through a dialyser, and further give small but quite appreciable lowerings of the freezing-point proportional to the concentration; thus dextrin gives a molecular weight 1,135, corresponding to $(C_6H_{10}O_5)_7$. Between solutions of colloids and semi-colloids there exists, then, a great difference, the latter showing themselves to be merely solutions of substances of very high molecular weight. With colloids, however, these experiments indicate that the substance does not dissolve in water, but is suspended in it. This view is confirmed by applying the phase-rule to such solutions. If they are true solutions, on freezing there would be three coexisting phases—ice, solution, and vapour—the system being mono-variant; whilst in the case of a sus-

pended solid, there would be another phase, and the system would be non-variant. That the latter is the fact is shown by there being only one temperature of freezing and not several corresponding with different concentrations. This conclusion is in agreement with that of Stöckl and Vanino, arrived at by a study of the optical properties of colloidal solutions of the metals. T. H. P.

2264. *Colloidal Solutions.* **K. Stöckl** and **L. Vanino.** (Zeitschr. Phys. Chem. 34. pp. 378–379, July 31, 1900.)—The authors adhere to their previously expressed opinion (Zeitschr. Phys. Chem. 30, 1898) that certain "colloidal" solutions of metals are merely cases of the prolonged "suspension" of very fine particles. The present note is a reply to a recent paper of Zsigmondy's [see Abstract No. 1698 (1900)], in which their conclusions were contested. F. G. D.

2265. *Supposed Isomerism of Red and Yellow Mercuric Oxide, and Surface-tension of Solids.* **W. Ostwald.** (Zeitschr. Phys. Chem. 34. pp. 495–503, Aug. 17, 1900.)—The author upholds the view that red and yellow mercuric oxide differ only in the size of the particles. The yellow oxide, being finely divided, is more soluble than the red oxide, just as small drops have a higher vapour-pressure than large drops. Experiments made on the action of mercuric oxide on potassium bromide solutions support this view. T. M. L.

2266. *Velocity of Solidification and Viscosity of Supercooled Liquids.* **H. A. Wilson.** (Phil. Mag. 50. pp. 238–250, Aug., 1900.)—In a previous paper [Proc. Camb. Phil. Soc. x. Part 1; Abstract No. 778 (1899)] the author arrived at the formula—

$$v=\frac{\mathrm{F}}{\mathrm{A}a}\,\frac{\theta_0-\theta}{\theta_0}$$

for the speed of growth of crystals in a supercooled liquid, where F = latent heat of fusion of 1 grm. of the solid, θ_0 = melting-point, θ = actual temperature at interface crystal—liquid, A = force required to give unit velocity to 1 grm. of the liquid diffusing through itself, a = thickness of transition layer between solid and liquid. Regarding F and a as const., the above formula may be written $v=\mathrm{C}\frac{s}{\mathrm{V}}$, where s = actual supercooling, V = viscosity, and C = a const. In testing this formula a difficulty arises owing to the fact that θ is not the same thing as the temperature of the cooling bath, since heat is evolved in solidification.

In the case of the supercooled melt of salol, the speed of solidification is sufficiently small to allow of an approximate determination of θ by observing the rise of temperature indicated by a fine thermocouple immersed in the melt as the surface of solidification passes it. In this case it is found that the results of experiment are very well represented by the formula $v=\mathrm{C}\frac{s}{\mathrm{V}}$. Experiments were also made with benzophenone and azobenzene, but in these cases the speed of solidification was too great to admit of a direct determination of θ being made, so that it was necessary to put θ = temperature of external bath. In spite of this, the above formula was found to represent the facts fairly well. F. G. D.

2267. *Change of Weight in Chemical and Physical Reactions.* **A. Heydweiller.** (Phys. Zeitschr. 1. pp. 527–529, Aug. 25, 1900.)—Experiments are

described similar to those of Landolt (Zeit. Phys. Chem. 12. p. 1. 1893), the reactions employed being (1) the action of iron on copper sulphate in neutral, acid, and alkaline solutions ; (2) copper sulphate and potash ; (3) solution of copper sulphate by water in neutral and acid solutions ; (4) mixing of copper sulphate solution and dilute sulphuric acid ; (5) action of oxalic acid on ammonia ; (6) action of barium chloride on sulphuric acid. The results obtained, combined with those of Landolt, show that the alterations of weight observed, of which the greatest is 0·229 mgrm., are, in all cases but one, decreases ; and further, are not proportional to the reacting masses. In many cases the changes are only produced in the presence of small quantities of foreign substances, more especially of acids or bases, and are hence probably due to some secondary action. T. H. P.

2268. *Influence of Chemically Indifferent Solvents on Reaction Velocities.* **N. Menschutkin.** (Zeitschr. Phys. Chem. 34. pp. 157–167, July 17, 1900.)—The results previously recorded (Berichte der Deutschen Chem. Gesell. 30. 2966, 1897), together with fresh experiments here described, are discussed with a view to elucidating the influence of various solvents on the reactions occurring between aromatic amino compounds and allyl-, or methyl-bromide, &c. The following conclusions are arrived at : Chemical reactions between organic compounds (non-electrolytes) in fluid systems take place in a similar manner, whether the compounds interact directly or in the presence of indifferent organic solvents. The regularities observed in the relations between the velocities of formation of the organic compounds examined depend on their chemical structure, and are observed both in the presence and in the absence of indifferent solvents. The study of such relations is more easily carried out in the presence of solvents. In the case of aromatic compounds exhibiting side-chain isomerism, the relative magnitude of the reaction velocities of the different isomers frequently depends on the nature of the solvent employed. N. L.

2269. *Velocity Constants of the Formation of Simple Ethers.* **W. Sagrebin.** (Zeitschr. Phys. Chem. 34. pp. 149–156, July 17, 1900.)—Experiments are described on the formation of ethers by the action of various alcohols on ethyl benzene-sulphonate. When one molecule of the sulphonate is used for 15 molecules of the alcohol the formation of the ether becomes a monomolecular reaction. The velocity constants are greatest for the primary alcohols of the fatty series, the value for methyl alcohol being the highest. In the case of the higher alcohols the constant is smaller, and diminishes regularly with the introduction of side-chains and with the greater or less distance of the hydroxyl group. The magnitude of the constant depends both on the structure of the carbon chain of the alcohol and on the influence of the same alcohol as a liquid medium. N. L.

2270. *Influence of the Medium on Reaction Velocities.* **G. Buchböck.** (Zeitschr. Phys. Chem. 34. pp. 229–247, July 17, 1900.)—The author has investigated the decomposition of thiocarbonic acid in aqueous solutions of organic and inorganic acids, various salts, &c. The conclusion is arrived at that the velocity of decomposition in such aqueous, isomotic solutions as are in equilibrium as regards the thiocarbonic acid is inversely proportional to the internal friction of the solutions. This result is shown to be in accordance with van't Hoff's theories. N. L.

2271. *Colour of Bromine and Iodine Compounds as Affected by Low Temperatures.* **J. H. Kastle.** (Chem. News, 82. pp. 90–91, Aug. 24, 1900; Amer. Chem. Journ. 23. No. 6.)—It is suggested that the characteristic red, orange, or yellow colour of bromine and iodine compounds may be accounted for by the supposition that such compounds are slightly dissociated, even in the solid state, so that the colour observed is that of the halogen itself. If this theory is correct, the colour of the halogen compounds should become lighter in tint, if not altogether white, on cooling to very low temperatures. Experiments with liquid air show that this is the case, for at $-190°$ iodoform becomes nearly white, lead iodide assumes a pale sulphur yellow tint, mercuric bromide becomes white, &c. N. L.

2272. *Heat Generated by Fibrous Substances when Wetted.* **L. Cobbett.** (Cambridge Phil. Soc., Proc. 10. pp. 372–376, Aug. 13, 1900.)—A thermometer wrapped round with a thick layer of dried filter paper rose to a maximum temperature of 132° C. when placed in a current of steam at 100° C. Similar results are obtained with cotton, silk, and wool, but asbestos produces no such effect, and it is suggested that the rise of temperature is due to the heat of combination of the water with the material of the fibre. A thermometer surrounded by asbestos or organic fibres remains at 100° C. for a considerable time when heated in a current of superheated steam, owing to the presence of moisture in the fibre. T. M. L.

2273. *Krypton.* **A. Ladenburg** and **C. Krügel.** (Preuss. Akad. Wiss. Berlin, Sitzb. 33. and 34. pp. 727–728, July 5, 1900.)—The authors have prepared Krypton from liquid air and find that its molecular weight is 59·01 and that there is about 0·00002 per cent. in the atmosphere. S. R.

2274. *Vapour-pressures of Hydrocarbons.* **B. Woringer.** (Zeitschr. Phys. Chem. 34. pp. 257–289, July 31, 1900.)—From the vapour-pressure curves of a series of sixteen aromatic and fatty hydrocarbons, the following laws are derived: (1) The difference between the boiling-points of any two members of a homologous series increases with the pressure. (2) The vapour pressure curves of two homologous substances have always relative positions such that the differences between the elevations of the boiling-point for the same increase of pressure form a rectilinear hyperbola. (3) The higher the pressure the more nearly do homologues obey Dalton's law, which states that by displacing the vapour-pressure curves parallel to the axis of temperature, they may be brought into coincidence. (4) The higher two homologues are in a series the more nearly does the hyperbola approach the limiting case of two straight lines. (5) The successive differences of boiling-point at constant pressure in a homologous series are in arithmetical progression, either increasing or diminishing with the pressure. (6) In all cases in which higher homologues are formed by the lengthening or branching of the side-chain of the benzene it is found that the elevation of boiling-point per CH_2 becomes smaller as the molecular weight increases. (7) When homologous compounds are formed by the addition of similar radicles to the benzene nucleus, the elevations of boiling-point thus produced are at the same pressure approximately equal, but diminish with the pressure. (8) In the case of aromatic position isomerides, the highest boiling-point is possessed by the compound in which the two substituent groups are adjacent. (9) All the laws holding for the normal boiling-points of isomeric compounds are obeyed at lower pressures. (10) Of isologous compounds at all pressures the aromatic are less

volatile than the aliphatic derivatives; and of the former class, those which have most side-chains and of the latter those which are the most saturated, are the least volatile. T. H. P.

2275. *Iron and Steel from the Standpoint of the Phase Rule.* **H. W. B. Roozeboom.** (Zeitschr. Phys. Chem. 34. pp. 437–487, Aug. 17, 1900.)—The experimental results of Roberts-Austen [see Abstract No. 238 (1900)] are treated from the standpoint of the author's theory of the formation and transformation of mixed crystals [Abstracts Nos. 678 and 679 (1900)] which has been verified in the case of a number of simple mixtures [Abstracts Nos. 680, 1321, 1322, and 1700 (1900)].

1. *Solidification-phenomena.*—The eutectic-point for iron and carbon is at 1,130° in a mixture containing 4·3 per cent. C. The carbon probably separates as pure graphite, but the iron separates in the form known as "martensite," as a solid solution of carbon and iron containing a larger proportion of iron than the liquid solution from which it separates; the limit of solubility of carbon in martensite at the eutectic-point is about 2 per cent. A melt containing under 2 per cent. C. therefore gives only martensite on solidification; one containing between 2 per cent. and 4·3 per cent. gives at first martensite, and when the eutectic temperature is reached a deposit of martensite containing 2 per cent. C., and graphite in the ratio of 97·7 per cent. to 2·3 per cent., the temperature remaining constant till the whole is solid; one containing more than 4·3 per cent. C. behaves similarly but deposits graphite first and then an eutectic mixture of martensite and graphite.

2. *Changes in solid mixtures with more than 2 per cent. C.*—The solubility of carbon in martensite appears to decrease with temperature, and on cooling from the eutectic-point (1,130°) where the solubility is about 2 per cent. to 1,000°, where the solubility is about 1·8 per cent., a further amount of graphite (called "temper-carbon") separates, and a conglomerate of graphite with a martensite containing 1·8 per cent. C. results in all cases where the total proportion of carbon in the mass is above 1·8 per cent. At 1,000° this conglomerate is converted at a uniform temperature into a mixture of "cementite" (Fe_3C) with either graphite or martensite according as the proportion of carbon is greater or less than 6·6 per cent. These changes would be considerably modified by cooling rapidly instead of slowly, and the chief effect of rapid cooling would be that a melt containing 2 to 6·6 per cent. C. would probably pass direct to a mixture of martensite and cementite without any intermediate separation of graphite. The transition-point for cementite $\rightleftarrows$ martensite + graphite would probably be best determined by heating pure cementite. From 1,000° to 690° the solubility of carbon in martensite falls again from 1·8 to 0·85 per cent. and carbon is deposited in the form of cementite, as was shown both by Osmond and by Roberts-Austen. At 690° carbon no longer forms a solid solution with iron and the remainder of the martensite changes abruptly into a fine conglomerate of "ferrite" (pure iron) and cementite, which is known as "perlite."

3. *Changes in solid mixtures with less than 2 per cent. C.*—These mixtures solidify to a homogeneous martensite and their homogeneous character can be preserved by rapid cooling. If there is more than 0·85 per cent. C. the martensite becomes saturated with carbon at some temperature between 1,000° and 690°, and deposits cementite until at 690° the remainder of the martensite passes abruptly into perlite (ferrite and cementite). If, however, there is less than 0·85 per cent. C. the martensite deposits iron and not carbon

or carbide on cooling. The γ-iron of martensite, which forms a solid solution with carbon, passes at 890° (the Ar_3 point) into β-iron and at 770° (Ar_2) into magnetic α-iron, neither of which dissolve carbon to any appreciable extent. The martensite deposits β-iron between 890° and 770° if the proportion of carbon lies between 0 and 0·35 per cent. and α-iron between 770° and 690° if the carbon lies between 0·35 and 0·85 per cent., in much the same way as ice separates from an aqueous salt solution; at 690° a martensite containing 0·85 per cent. C. is saturated both with ferrite (α-iron) and cementite (Fe_3C) and passes into perlite, this temperature corresponding with the eutectic-point of ice and salt.

The behaviour of iron-carbon mixtures is also discussed on the assumption that other modifications, such as "Austenite," exist, and a discussion is given of the state of the dissolved carbon and its diffusion through the solid iron.

T. M. L.

2276. *Thermodynamics of the Voltaic Cell.* **H. S. Carhart.** (Phys. Rev. 11. pp. 1–13, July, 1900.)—After a theoretical introduction in which the author obtains the well-known Helmholtz equation, he proceeds to describe measurements of the Peltier effects at the metal-liquid junctions in the Daniell cell. The method of procedure was as follows: The solutions of zinc and copper sulphates were chosen of such strengths that their specific conductivities were practically equal. The current was allowed to flow in one direction for a certain time and the difference of temperature between the two metal-liquid junctions measured by a thermocouple. This difference was then corrected for the disturbing effects of conduction and radiation. The current was allowed to flow in the reverse direction (after equalisation of temperature) until the same quantity of electricity had passed, and a new (corrected) difference of temperature obtained. The mean of these two differences gives the true difference corrected for loss of heat by radiation and conduction, and for unsymmetrical effects due to concentration-changes at the electrodes and inequalities in the Joule heat developed in the neighbourhood of the electrodes. The value so found experimentally agreed very well with the value calculated from the specific heats of the solutions and the known constants of the cell.

F. G. D.

2277. *Graphical Thermodynamics of Electrochemical Processes.* **F. Haber.** (Phys. Zeitschr. 1. pp. 361–371, June 2, 1900.)—This is an exposition of the graphical method employed by Luggin in his lectures on theoretical electrochemistry, wherein the free energy and temperature are chosen as co-ordinates, the heat of the reactions being taken to be independent of the temperature when the processes occur without work being done, and the free energy being taken to be a linear function of the temperature. The action in Bredig and Knüpffer's thallium cell is specially considered, and Bodländer's views on the relation of E.M.F. to solubility are graphically explained. R. E. B.

2278. *Theory of Transition-cells of the Third Type. I.* **E. Cohen.** (Zeitschr. Phys. Chem. 34. pp. 179–186, July 17, 1900.)—The E.M.F. of a transition-element of the third type, which depends on the conversion of a metastable into a stable hydrate of a salt, is given by the equation $E = q\frac{P-T}{p}$, where q is the heat developed in the change, P the absolute temperature of the transition-point, and T the absolute temperature of the cell; the temperature

coefficient, $\frac{dE}{dT}$, is $-\frac{q}{P}$. The value of q has been determined in the case of the hydrates $ZnSO_4.7H_2O$ and $ZnSO_4.6H_2O$ from Thomsen's numbers to be -3609 calories at 18°, whilst a direct determination at 39° gave $q = -3752$ calories. From this value the temperature coefficient is calculated to be $-0{\cdot}52$ millivolts, whilst Jaeger's values for the E.M.F. of Clark cells containing the two hydrates gave $\frac{dE}{dT} = -0{\cdot}50$ millivolts at 39°, showing a very satisfactory agreement between the calculated and observed values. T. M. L.

2279. *Calculation of the Conductivity of Aqueous Solutions Containing Hydrochloric and Sulphuric Acids.* **J. Barnes.** (Nova Scotian Inst., Trans. 10. pp. 129–138, 1899–1900.)—The conductivities of dilute mixtures of hydrochloric and sulphuric acids have been calculated according to the method of MacGregor (Trans. N.S. Inst., 9, 101, 1895–6) from those of the simple solutions and have been compared with the observed conductivities. The differences do not exceed 0·5 per cent. when the concentrations of the acids are not greater than those of normal solutions, and the assumption made, that in these dilute solutions the sulphuric acids dissociates into 2H and SO_4, is therefore justified [see also Abstract No. 988 (1900)]. T. M. L.

2280. *Depression of the Freezing-point by Mixtures of Electrolytes.* **J. Barnes.** (Nova Scotian Inst., Trans. 10. pp. 139–161, 1899–1900.)—The specific molecular conductivities of potassium and sodium chlorides and of hydrochloric acid were determined at 0°, and the values of $\frac{\mu_{18} - \mu_0}{\mu_{18}}$ were found to have almost constant values, viz., 0·366, 0·381, and 0·301 respectively. The observed molecular depressions of the freezing-point were 1·86, 1·90, and 1·85 respectively. The ionisation-coefficients of the mixtures were calculated by MacGregor's method, and hence the depressions of the freezing-point were ascertained. These were compared with the observed depressions in mixtures of potassium and sodium chlorides, sodium chloride and hydrochloric acid, and in mixtures of the three chlorides, and the deviations were found to be in all cases within the limits of experimental error. T. M. L.

2281. *Solubility of a Mixture of Salts Possessing a Common Ion.* **C. Touren.** (Comptes Rendus, 131. pp. 259–261, July 23, 1900.)—The author in continuation of previous work [see Abstracts Nos. 1527 and 1706 (1900)] has determined the solubility of potassium nitrate in solutions of potassium carbonate, and potassium bicarbonate respectively. If the results be plotted as curves in which the ordinates represent the number of K-ions proceeding from the nitrate and the abscissæ the number of K-ions proceeding from the carbonate or bicarbonate (assuming complete ionisation) it is found that the curves so obtained coincide pretty closely with the corresponding curve obtained from the chloride and nitrate so long as the concentrations are not too high. Above a certain limit there ceases to be any coincidence owing to variation in the degree of ionisation. F. G. D.

2282. *Electromotive Force and Optical Constants of Chromium.* **F. J. Micheli.** (Archives des Sciences, 10. pp. 122–131, Aug., 1900.)—The passivity of iron, which appears to be due to the formation of a film of oxide, is accompanied by a change in the optical properties of the surface as indicated by the plane of polarisation of a reflected ray of polarised light. Active

chromium, however, exhibits *no* change when converted into passive chromium by immersion in nitric acid, and it is therefore concluded that no film of oxide is formed in this case. By heating with fused zinc chloride, chromium becomes covered with a layer of oxide which can be detected by the optical method, but this is accompanied by increasing activity and the chromium can also be brought into the passive state by immersing in nitric acid without disturbing the film, showing that the film of oxide has no influence on the active or passive state of the metal.

Whereas Hittorf and Ostwald state that active chromium gradually becomes passive on exposure to the air, the author found that passive chromium gradually became active. [*Cf.* the following Abstract.]

T. M. L.

2283. *Passive State of Metals.* **W. Hittorf.** (Zeitschr. Phys. Chem. 34. pp. 385–402, Aug. 17, 1900.)—The combination, Fe | NO_3Na, CrO_4H_2 | Pt has an E.M.F. of 1·82 to 1·84 volts on open circuit, as measured by a quadrant electrometer; with a Siemens galvanometer the E.M.F. gradually decreased owing to the passage of the current, and when short-circuited the E.M.F. fell almost instantly to 0·1 volt, the relatively large current causing the iron to assume the passive state very rapidly. The passive state is, however, unstable, and on open circuit the E.M.F. rose again in twenty minutes to 1·82 volts; the iron also becomes active again when washed and dried in the air, and it is therefore concluded that the passive state cannot be due to a film of oxide since this would not be removed by this treatment. The passive state is assumed still more rapidly if the current through the cell is increased by an external E.M.F., and under these conditions the iron is no longer attached at all by the $-NO_3$ ions, but oxygen and nitric acid are formed; under similar conditions chromium yields chromic acid and not free oxygen; with no additional E.M.F. iron never becomes passive in *acid* solution. If a solution of copper or silver nitrate is used in place of sodium nitrate, the iron immediately becomes inactive, but addition of nitric acid restores the activity and causes the immediate precipitation of copper or silver, unless a strong current is kept passing through the cell. A momentary reversal of the current immediately renders the iron active. Potassium bichromate in place of sodium nitrate gave 0·95 volt, falling to 0·17 when short-circuited for seven minutes, and sodium acetate gave 1·49 volts, falling in a few minutes to 0·15 volts when short-circuited; but with sodium sulphate the passive state could only be realised with an external E.M.F. of 2 volts, and disappeared at once on open circuit. Iron is passive in strong nitric acid, but this state does not persist when removed from the acid and in acid of sp. gr. 1·2, it can only be kept from dissolving as the anode for a large current; similarly chromic acid requires a large current to protect the iron, and in dilute sulphuric acid the solution of the iron, which cannot be stopped when once started, is only prevented by an external E.M.F. Sodium hydroxide in place of sodium nitrate gave an E.M.F. of 1·59 volts, falling in a few minutes to 0·16 volt when short-circuited, owing to the iron becoming passive.

In addition to chromium and iron, nickel and cobalt possess the power of assuming the passive state, though in a much smaller degree. Silver and lead also behave similarly when in contact with sulphate solutions. [*Cf.* preceding Abstract.]

T. M. L.

2284. *Decrease of Osmotic Pressure by Ion-charges.* **V. v. Türin.** (Zeitschr. Phys. Chem. 34. pp. 403–408, Aug. 17, 1900.)—Owing to the mutual attraction

of the ions the osmotic pressure in a spherical vessel is reduced according to the equation—

P (dynes per sq. cm.) = $1{\cdot}158 \times 10^{11}.k.D^{-1}.q.a^{-1}$, where D is the dielectric constant of the solution, k the concentration, $\pm q$ the charge on each ion, and a the radius of the sphere. T. M. L.

2285. *Electrolytic Potassium Chlorate.* **A. Brochet.** (Ind. Électrochim. 4. pp. 41–43, April, 1900; from L'Électro-Chimie, p. 55, 1900.)—A continuation of his investigations [Abstract No. 691 (1900)] has lead the author to the following conclusions: In cold, practically neutral (slightly alkaline or acid) solutions of potassium chloride, the chlorate is always a secondary product, the only primary product of the electrolysis being hypochlorite, whose reduction can be prevented by the addition of bichromate, after E. Müller's method. A certain portion of the hypochlorite is then, by the generation of oxygen, transformed into chlorate, in a manner that is uncertain; there seems to be no electrolysis of water. The transformation is of a complex nature, and the author appears to ascribe an essential part to the bichromate. In hot [there is evidently a misprint in the paper] alkaline solutions, the conversion of hypochlorite into chlorate is more rapid but never complete. Whether or not there be a primary formation of chlorate in more strongly alkaline solutions remains undecided. On the whole, the author sides with Oettel. [See also Abstract No. 1899 (1900).] H. B.

2286. *Electrolysis of Concentrated Hypochlorite Solutions.* **A. Brochet.** (Comptes Rendus, 131. pp. 340–343, July 30, 1900.)—In continuation of previous experiments on the electrolytic production of chlorates [see Abstracts Nos. 691 and 1899 (1900)] the electrolysis of alkaline solutions of sodium hypochlorite has been studied on the same lines as before. The results are represented by curves. The proportion of hypochlorite decreases rapidly at first and then more slowly until it becomes constant, whilst the amount of chlorate increases at first rapidly and then more slowly. The kathodic reduction remains for some time constant at 97–99 per cent. and then rapidly diminishes, whilst the anodic oxidation is at first constant at about 50 per cent. and afterwards increases rapidly. The amount of alkali present has but little influence on the reduction. The general conclusion arrived at is that the electrolysis of hypochlorite solutions in its later stages resembles that of chlorides and tends towards the same limits. There is hence little hope of obtaining concentrated hypochlorite solutions by direct electrolysis. N. L.

2287. *Electrolytic Reduction of Difficultly Reducible Substances in Sulphuric Acid Solution.* **J. Tafel.** (Zeitschr. Phys. Chem. 34. pp. 187–228, July 17, 1900.)—The behaviour of caffeine was more especially studied with a view to elaborating a method which would allow of the systematic regulation of the experimental conditions and afford a general method for the preparation of compounds by electrolytic reduction. The reduction of caffeine in sulphuric acid solution is only possible when the kathode consists of a material (lead or mercury) showing a high kathode potential. The disturbances often observed in reductions are found to be due to the contamination of the kathode by traces of foreign metals, and are best avoided by coating the surface of the electrode with lead sponge, electrolytically deposited. The reduction is hastened by a rise of temperature, but only to a slight extent. The current

yield, within certain limits, is nearly proportional to the current. For equal concentrations of caffeine and equal currents per litre of liquid at the kathode ("current concentration") the current density has relatively little influence on the course of the reaction, the reduction increasing slightly as the current density diminishes. In apparatus of similar construction but different size the reaction follows the same lines provided the initial concentration of the substance, the current concentration, and the relation between the surface of the kathode and the volume of the kathode liquid are the same in each case. N. L.

2288. *Electrolytic Estimation of Lead.* **C. Marie.** (Chem. News, 82. p. 51, Aug. 3, 1900; from the Bull. Soc. Chim. 23. No. 12.)—In order to estimate lead in such insoluble compounds as the chromate and sulphate, the substance is dissolved in nitric acid with the aid of ammonium nitrate, the liquid diluted, and the electrolysis carried out at 60–70° in the usual manner. Five grammes of ammonium nitrate should be used for 0·3 gm. of lead sulphate, and the diluted solution should contain 10 per cent. of nitric acid. The process is applicable to lead glass, which is subjected to a preliminary treatment with a mixture of sulphuric and hydrofluoric acids. N. L.

2289. *Electrolytic Estimation of Cadmium.* **D. Balachowsky.** (Comptes Rendus, 131. pp. 384–387, Aug. 6, 1900.)—Pure, adherent deposits of cadmium, in a state suitable for washing and weighing, may be obtained by dissolving 1·5–2 grammes of the cadmium salt in 150 c.c. of water, adding 7–10 c.c. of nitric acid, and electrolysing in a copper-coated Classen capsule at 60°. The E.M.F. may rise from 2·8–3·5 volts, and the current density from $ND_{100}=0·4–0·6$ ampere. Cadmium may also be estimated by the process advocated in the case of bismuth [see following Abstract], the electrolysis being carried out at 40–60° in a roughened capsule and 2–4 per cent. of urea, formaldehyde, or acetaldehyde being added to the solution. N. L.

2290. *Electrolytic Estimation of Bismuth.* **D. Balachowsky.** (Comptes Rendus, 131. pp. 179–182, July 16, 1900.)—The bismuth salt, to the extent of 0·5–0·8 gms., is dissolved in 5–6 c.c. of nitric acid diluted with 150 c.c. of water, 3–4 gms. of urea added, and the liquid electrolysed for six hours at about 60°, using an E.M.F. of 1·5–1·9 volts, and a current density of 0·03–0·04 ND_{100}. By operating in this manner closely adherent deposits of metallic bismuth are obtained which may be readily washed and weighed. The absence of large quantities of chlorides, bromides, or iodides is essential, and unpolished platinum electrodes should be used. N. L.

2291. *Feeding Apparatus for Electrolytic Cells.* **R. Girouard.** (Elektrochem. Zeitschr. 7. pp. 111–113, Aug., 1900.)—A description, with figure, of an arrangement for conveying liquid at a regular rate from a reservoir to the electrolytic cell; the liquid is caused to pass through a capillary tube, from which it issues in drops, so that there is no electrical contact between the liquid in the reservoir and that in the cell. T. H. P.

2292. *Electro-chemical Industry in France.* **L. Guillet.** (Génie Civil, 37. pp. 146–149, June 30; 172–173, July 7; 186–190, July 14; 219–220, July 21; 229–231, July 28; 254–256, August 4, 1900.)—This review of the progress of the chemical industry in France in recent years covers the whole extent of the industry, but only the portions relating to electro-chemistry and electro-metallurgy are referred to in this Abstract,

Caustic soda is produced by two companies, using the Greishem process, and the Outhenin-Chalandre process respectively. The works are located at Lamothe and at Montiers. The former produces 2,500 tons per annum. Alkalies and bleaching powder are produced by the *Société Fives-Lille* at Bozel, in Savoy, where 8,000 H.P. is available. The *Société d'Electro-chimie* produces potassium permanganate, ammonium persulphate, chlorates and perchlorates at St. Michel. The second of these is obtained by electrolysis of ammonium sulphate. It is used in bleaching operations and in photography. Chlorates and perchlorates are also made by Berges, Corbin & Co., at their works at Chedde, in Savoy. The total French output of chlorate is estimated to be 3,850 tons, of which total 3,000 tons is produced by the two electrolytic works named above. Perchlorate of ammonium is a new chemical, used in preparing mining explosives. The manufacture of phosphorus by the electric furnace method is about to be introduced into France. Hitherto the French production of this chemical has been solely due to the operation of the old chemical reduction process. Calcium carbide is produced by eight factories situated in the eastern districts of the country. The factories are at Sechilienne, Epierre, St. Michel, Giffre, N. D. de Briançon, Bellegarde, Froges and St. Beron. In the aggregate these factories have at their disposal 14,400 H.P., for carbide production, but the whole of this power is not yet used in the manufacture. J. B. C. K.

2293. *Electrolytic Drilling and Slotting of Metals.* **S. Cowper-Coles.** (Elect. Rev. 47. pp. 131–132, July 27, 1900.)—The advantages claimed for this method are that hard-tempered plates can be drilled in any position with any shape of hole without removing the temper. The apparatus in its simplest form consists of a nozzle, the narrow end of which is the shape of the desired hole. The nozzle is provided with inlet and outlet pipes for the electrolyte, and with a baffle plate to facilitate circulation. A metal kathode rod is also provided. The nozzle is pressed against the plate which is to be drilled, and an electric current is passed through the electrolyte, using the plate itself as anode. Either sulphuric acid solution, or brine, may be used as electrolyte. The article is illustrated. J. B. C. K.

2294. *Intermittent and Continuous Carbide Furnaces.* **O. Frölich.** (Zeitschr. Elektrochem. 7. pp. 1–10, July 5, 1900.)—This is a reply to Carlson's paper [see Abstract No. 1129 (1900)] in a previous issue, the author pointing out that in Carlson's comparison of the two classes of furnaces (to the detriment of the continuous furnace), he had taken as his type of continuous furnaces those in which the carbide is tapped out in the fluid condition, whereas in the better class of furnace of this type, such as that of Horry, and of Siemens and Halske, this is not the case. Applying Carlson's arguments and calculations one by one to the furnaces of the last-named type, he shows that many of Carlson's deductions must be modified or reversed.
W. G. M.

2295. *Electric Furnaces for Calcium Carbide.* **R. Memmo.** (Elettricità, Milan, 19. pp. 466–470, July 28, 1900.)—Furnaces may be divided into two classes: those in which the carbide is maintained liquid, and withdrawn from time to time during the action of the furnace from an orifice at the bottom; and those in which the carbide forms a solid block, which is taken out after partial cooling of the furnace. The author compares the advantages and disadvantages of the two types, summing up as follows:—

The former type wastes heat in maintaining the carbide liquid, and must always be worked at full power; it can, however, be worked continuously, and in this respect saves the heat lost in cooling the block furnaces. The product is impure but homogeneous, and gives a slow and regular evolution of gas.

The block furnaces are very efficient in action, but the extraction of the block occasions waste of heat. They can be worked at low charges with but slight loss of efficiency. The attendance necessary during action is small, but the blocks after extraction require considerable working. The carbide is very rich in gas, but not homogeneous, and gives a violent action with water.

G. H. B.

2296. *Electrolytic Zinc and Utilisation of Anode Gases.* **J. Rontschewsky.** (Zeitschr. Elektrochem. 7. pp. 21–25, July 12, and 29–32, July 19, 1900.)—This is an account of a series of experiments made with a view to utilising the oxygen given off at the insoluble anode when submitting solutions of zinc sulphate to electrolysis. For the simultaneous production of, for instance, peroxide of lead and metallic zinc, the author employs an anode of the former metal, with the addition of a variable percentage of sodium chloride, in order to provide the necessary acid suitable for rendering the lead soluble. A number of trials were made in order to obtain the best results with regard to temperature, concentration, current density, and rate of circulation of liquid. Other experiments are also given with the view to producing lead chromates. In all cases the zinc deposited was of a coherent and crystalline character.

O. J. S.

2297. *Barrel Method of Nickel Plating.* **G. Dary.** (Électricien, 20. pp. 49–50, July 28, 1900.)—The cycle and motor-car industries have greatly increased the demand for nickel-plated articles. The older method of plating, which involved the handling of each separate article, is no longer practicable for the innumerable small articles, such as nuts, bolts, &c., which now require to be nickel plated.

An English patent, owned by the Electrolytic-plating Apparatus Co., has solved the economic difficulty presented by the plating of these small objects. The preliminary treatment involves the usual boiling with strong potash solution, rinsing in water, and immersion in a nitric acid bath; but these and the after electrolytic deposition of the nickel, are all carried out in the one piece of apparatus. This consists of a perforated wooden barrel, mounted so that it may be rotated at any desired speed in the tanks containing the various cleaning and depositing solutions. The barrel and its mountings are suspended by a rod which rests on the tanks, and the whole can be raised or lowered by means of pulleys. The method of working is as follows: The barrel is filled one-half or two-thirds with the articles, and is then lowered into the cleaning or depositing solutions. The speed of rotation varies according to the form of the articles to be plated—a speed of fifty-five revolutions per minute being found the best for certain forms. The electrical contact between the articles in the barrel and the negative leads is effected by means of the metal rod which carries the barrel and the trunnions on which it revolves. From the latter metallic strips run along the interior of the barrel, and thus make contact with all the articles which it contains.

A current of 10 amperes at 6 volts pressure will plate 20 kgs. of metallic objects in four hours, the barrel used for such a charge being 0·75 metre in length. Sawdust is used to dry the articles, after they have been thoroughly

washed with water. The cost of nickel-plating by this process lies between 0·80 and 2·50 francs per kg., according to the form of the articles requiring to be plated. J. B. C. K.

2298. *Electrolytic Cleaning of Metals.* **J. Reyval.** (Écl. Électr. 24. pp. 91–92, July 21, 1900.)—After a reference to the disadvantages of the older methods of preparing metal surfaces for electroplating and other purposes, and to the previous attempts to make use of electrolysis for this work, the author gives a brief description of the method patented by the "Vereinigte Elektricitäts Aktien Gesellschaft" of Vienna (French Patent, 292333 of 1899). This method is applicable to all metals. A salt of one of the alkali metals is used to make up the electrolyte, and carbon, or a metal unattacked by the electrolyte or its constituent ions, is used as the second electrode. Aluminium and zinc are connected as kathodes in such a solution, while iron, copper, or alloys of the latter metal are made the anodes. In the former case an aluminate or zincate is formed at the kathode on passing a current through the solution, and as the solution of this salt diffuses into the bath it meets the free acid formed at the anode, and a precipitation of zinc or aluminium hydrate occurs. In the latter case, an alkaline hydrate is formed at the kathode, and this diffusing into the bath produces a precipitate of the iron or copper dissolved at the anode. In each case, therefore, the electrolyte is *regenerated*, while the metal dissolved is collected as a hydrate from the bottom of the bath. In the case of costly metals, such as copper, this recovery of the metal as hydrate is a decided advantage. For cleaning steel sheets before galvanising, a solution of sodium sulphate is used as electrolyte, and thicker sheets of iron are used as kathodes. A current density of 140 amperes per sq. metre can be obtained with an E.M.F. of between 4 and 8 volts. Practical tests have proved the method to be rapid and economical. J. B. C. K.

REFERENCES.

2299. *Extraction of Oxygen from the Air.* **G. Claude.** (Comptes Rendus, 131. pp. 447–450, Aug. 20, 1900.)—The author refers to the commercial importance of obtaining air rich in oxygen, and the possibility of doing this without expenditure of energy. He shows that a mixture of nitrogen and oxygen containing 50 per cent. of the latter would already effect a great saving with respect to the quantity of diluting nitrogen. He has tried the effect of using various solvents at low temperatures, but the small difference between the solubilities of nitrogen and oxygen showed that a process based on this method would be quite useless. F. G. D.

2300. *Liquid Crystals.* **R. Schenck.** (Phys. Zeitschr. 1. pp. 409–413, June 23, and 425–428, June 30, 1900.)—A *résumé* of the researches made up to the present on liquid crystals. T. H. P.

2301. *Electro-chemistry in a Dye and Print Works.* **A. E. Sunderland.** (Electrician, 45. p. 703, Aug. 31, 1900. Paper read before the Society of Dyers and Colourists at Bradford Technical College.)—The author first describes the principles underlying the oxidation or reduction of organic dye products in the electrolytic cell, and then describes in detail some of the methods worked out by Goppelsroeder in 1886, for applying these principles in practice. The author's own experiments upon the Diazo compounds are next dealt with, and an electrolytic method for producing the water-mark or "Moire" effects, upon piece goods is described. The paper closes with a brief account of the Schreihage method of hot pressing, which is simply an application of resistance heating to this special problem. J. B. C. K.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

2302. *Single Cylinder Farcot Engine at the Paris Exhibition.* (Engineer, 89. p. 664, June 29, 1900.)—That a 1,000 H.P. engine should in these days of high speed multiple expansion engines be built with a single cylinder, is a significant fact, and emphasises the point that so far as thermal efficiency is concerned, there is not much to choose between the two systems.

The cylinder is 39·37 inches diameter, and the engine has 4 ft. 5 in. stroke, and is designed to run at 78½ to 79 r.p.m. The steam consumption is as follows:—

Cut-off.	B.H.P.	Steam for I.H.P. hour.
$\frac{1\cdot5}{10}$	700	13·5
$\frac{2}{10}$	1,020	14·4
$\frac{3}{10}$	1,230	16·4

As the boiler pressure is only 85 lbs. per square inch this is a very fair record.

The two-phase alternator driven by this engine is nominally 750 kilowatts [see Abstract No. 2318 (1900)]. The crank shaft is 15·75 inches diameter at the exciter bearing, and is swelled to 25·6 inches at the centre, where the alternator flywheel is keyed on. Corliss valves are used, and they are placed in the covers at either end of the cylinder. The trip gear employed to work the valves is that usually employed by the Farcot firm, all the wearing parts being made of hardened steel. L. S. R

2303. *Superheated Steam.* **P. Schou.** (Northern Soc. Elect. Engin., Proc. 5. pp. 21–27; Discussion, pp. 27–30, 1899.)—Schmidt, of Cassel, first introduced complete plant working with superheated steam. Over two hundred plants are now running most successfully on his plans. One 750-H.P. plant has been running in a rolling mill for three and a half years, consuming 8·75 lbs. of steam per I.H.P. hour, and is now to be followed by a 4,000-H.P. plant in the same works. Tests made in Ireland on a 70-H.P. engine gave 10·2 lbs. of steam and 1·4 lbs. of coal per I.H.P. hour. The two great difficulties were to find tubes that will stand the excessive heat of the superheater and to ensure the proper lubrication of the engine.

The Schmidt engine has the following advantages: (1) H.P. cylinders require no jackets; (2) heat absorbed by the H.P. cylinder walls during admission is not lost but goes to heat the receiver; (3) L.P. cylinder is heated by receiver steam; (4) H.P. piston is cooled inside by receiver steam; (5) only one stuffing box is in contact with receiver steam.

For double-acting steam engines Schmidt has a novel idea of mixing the two classes of steam, superheated and saturated, and the governor regulates the supply of these two classes of steam in connection with the cut-off. The arrangement for effecting this is fully described.

The superheater is composed of a series of lap welded coils from 1 inch to 2 inches diameter, according to the size of the superheater, and they are bent into coils or zigzag to suit the existing circumstances. They are heated either direct by the escaping flue gases or independently by an auxiliary furnace.

Schmidt also fits an economiser behind the superheater to still further

reduce the temperature of the escaping gases. Distilled water only is used in this economiser to avoid corrosion and cleaning, and it is used to heat the feed water supplied to the boiler. As the distilled water which leaves the feed-heater is hot it does not cause the gases coming in contact with the economiser tubes to condense and deteriorate the tubes. It is claimed that an economy of 20 to 25 per cent., even on the best compound engine, can be obtained by the use of this kind of heater. Two large Schmidt superheaters are now being put down in Manchester for electric traction purposes.

Discussion.—**Raworth** pointed out that with superheated steam, joints which would leak with saturated steam remained tight when superheated steam was used, and Mr. Schmidt confirmed this statement. **Mannock** had used a slight superheater for many years, but had experienced great difficulty with the lubrication and corrosion of the tubes. **Browett** pointed out that cost of fuel for generating current was between ½d. and 1d. per unit, and that the saving of one-third of this by this superheater was very little on total cost, and might be balanced by extra charge for maintenance of superheater. **A. B. Mountain** had seen great difficulties in use of superheated steam with piston-rods, packing, and valves in double-cylinder engines, and mentioned that Robey & Co. had successfully employed the mushroom type of valve some years ago. L. S. R.

2304. *Production and Utilisation of Superheated Steam.* **R. S. Hale.** (Eng. Mag. 18. pp. 722–728, Feb., 1900.)—After reviewing the forms and positions of superheaters, the author concludes that in general the best position for a superheater is within the flues of a boiler, where the heat, although insufficient to overheat the tubes is yet sufficient to admit of comparatively small area of superheating surface, and is further utilised by the remainder of the boiler-heating surface. The relative advantages of different kinds of superheaters are discussed and the economy by the use of superheated steam is given. The author believes steam of 500 lbs. pressure superheated to 650° F. to be one of the probabilities of the future. J. T. R.

AUTOMOBILISM.

2305. *Rochet Automobile.* (Locomotion Automobile, 7. pp. 422–425, July 5, 1900.)—The standard type of mechanism for motor vehicles, made by the firm of Rochet, is described with the aid of photographic illustrations.

It consists essentially of a tubular underframe to which the mechanical parts and the carriage body are directly attached, and which is supported from the front axle by a single leaf spring placed transversely to the length of the frame, and from the back axle by single leaf springs one at either side below the longitudinal frame members.

The engine is attached to the frame immediately behind the front axle, and drives, through a cone friction clutch, a longitudinal shaft, at the back end of which is the speed changing mechanism. From this gear, which permits of four changes of speed in the forward direction and one reverse speed, the power is transmitted through bevel gear to a transverse shaft carrying the differential gear, and at its ends sprocket pinions which drive the rear road wheel through pitch chains. The vehicle is controlled by three band brakes. The steering is on the Ackerman system, the steering wheel pivots being directly controlled from the steering-bar without the interposition of any gear.

The petroleum spirit engine is a modified Daimler, and has two vertical cylinders, the pistons of which are coupled to cranks at 180°, thus securing balance of the mechanical parts at the expense of irregularity of impulse, due to both explosions taking place in one revolution. The cranks, and, as far as possible, the mechanism for actuating the exhaust valves, are enclosed in an oil-tight gear-case. The governor is of the centrifugal type, and operates on the engine by preventing the lifting of the exhaust valves. Ignition is electric, a storage battery and induction coils being carried. The cylinder bodies and heads are water-jacketed, the water being circulated by a rotary pump and passed through a cooler on its way back to the tank. The normal speed of the engine is 750 r.p.m. and the power developed from 6 to 8 B.H.P.

The speed-changing gear, which forms one of the principal features of the Rochet vehicle, consists of four pairs of spur wheels, each pair being mounted on a spindle fixed to a plate which may be rotated concentrically with the longitudinal shaft driven by the engine through the friction clutch. At the back end of this shaft is a spur wheel with which one wheel of either pair of movable wheels engages. The other wheel of each pair may, by suitable rotation of the plate be caused to engage with a spur wheel on a short shaft which drives the differential shaft through bevel gear. The special advantage claimed for this gear is that owing to the distribution of the pitch circles, the wheels roll into gear instead of engaging by side contact, with resulting diminution in wear and tear, and noise on changing speed. C. R. D'E.

2306. *Massignon's Change Speed Gear.* (Locomotion Automobile, 7. pp. 528–530, Aug. 16, 1900.)—This article describes an arrangement of belt transmission and epicycloidal gear by means of which variable speed, forward or reverse, may be imparted, from a shaft driven by a motor at constant speed, to a countershaft from which the road wheels of a motor vehicle may be driven. The arrangement illustrated has not been practically applied with success to motor vehicles. C. R. D'E.

REFERENCES.

2307. *Standard Rules for Boiler Engine Trials.* (Elektrotechn. Zeitschr. 21. pp. 352–355, May 3, 1900.)—This article gives a very complete set of rules for conducting standard boiler and engine trials, issued jointly after careful revision by the following Societies: "Verein deutscher Ingenieure," "Internationaler Verband der Dampfkessel - Ueberwachungsvereine," and "Verein deutscher Maschinen-bauanstalten," and is well worth consulting by those conducting or interested in boiler and engine trials. L. S. R.

2308. *Steam Piping and Accessories.* **W. D. Ennis.** (Street Rly. Rev. 10. pp. 12–15, Jan. 15; 93–95, Feb. 15; and 135–136, March 15, 1900.)—An article containing several drawings, showing different arrangements of steam piping.

GENERAL ELECTRICAL ENGINEERING.

2309. *Practical Primary and Secondary Cells with Electrolytes of Constant Conductivity.* **E. W. Jungner.** (Elektrochem. Zeitschr. 7. pp. 102–104, Aug., 1900.)—The primary cell has the following construction : The positive electrode consists of powdered silver peroxide (so-called "ozonised" silver) mixed with a binding material to form a porous mass which is contained in a net of nickel gauze. The negative electrode is a copper net containing finely divided copper. The electrodes are arranged alternately in an ebonite vessel and are separated by thin layers of asbestos paper moistened with caustic alkali solution ; the conducting wires from similar electrodes are joined together. The cell is provided with a stone cover containing holes for the escape of any gas which may be evolved by overcharging. The reactions taking place during the discharge of such an element are—

$$Ag_2O_2 + 2KOH + 2Cu = Ag_2O + K_2O + 2CuOH$$

$$K_2O + H_2O = 2KOH$$

and—

$$2\,CuOH = Cu_2O + H_2O$$

the whole action being expressed by the equation—

$$Ag_2O_2 + 2\,KOH + 2Cu = Ag_2O + 2KOH + Cu_2O.$$

The E.M.F. developed by the cell is 0·93 volt. If, after discharge, a current be passed through the cell in the opposite direction, the above reactions will take place in the reverse sense. By making the negative electrode of ferrous hydroxide and the positive of hydrated manganese peroxide, the electrolyte will still remain unchanged when a current passes, the reaction in the cell being expressed by—

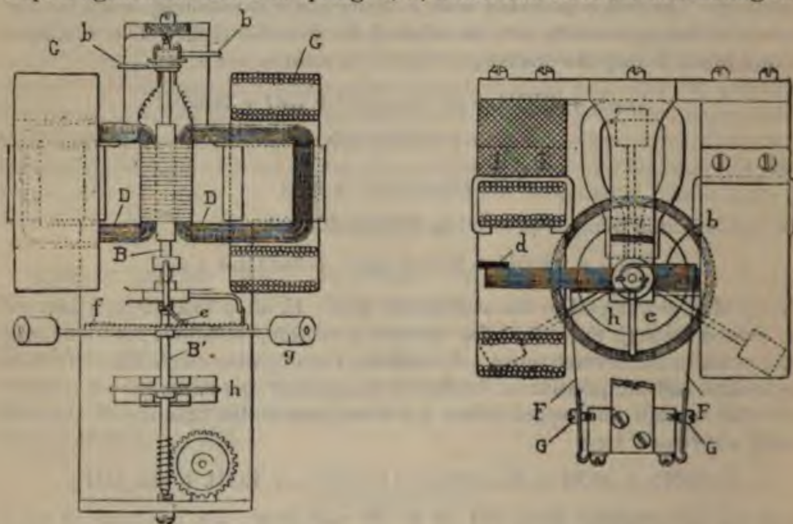
$$Fe\,(OH)_2 + KOH + Mn\,(OH)_4 = Fe\,(OH)_3 + KOH + Mn\,(OH)_3.$$

Such an accumulator gives out 40 to 50 watt-hours per kilogram of total weight, the power being 5 to 10 watts. The internal resistance is very small, owing to the layer of liquid between the electrodes being very thin. The electrodes have a long life since the small changes of volume during charging or discharging have only a slight effect on their compactness. As no secondary reactions can take place in the cells they can be used almost indefinitely without diminution of capacity. Finally, charging or discharging may be interrupted or carried too far without injury to the accumulator which is besides almost uninfluenced by dampness or changes of temperature and requires but little attention. T. H. P.

2310. *Electromagnetic Ticket Printing and Delivering Device.* **F. Krull.** (Elekt. Runds. 17. pp. 193–194, July 1, 1900.)—In this device there is an ebonite coin-chute having three pairs of contacts which are successively connected together by the coin as it falls. The first two sets serve to complete the circuits of two electromagnets arranged respectively on the ends of an oscillating balance-beam and of stationary electromagnets arranged opposite the moving electromagnets, in such a manner that the balance-beam is oscillated first in one and then in the other direction. This motion is utilised

in reciprocating a slide which pushes the lowermost of a pile of tickets forward into position beneath a printing stamp, and at the same time pushes a previously printed ticket out of the machine. The third pair of contacts complete the circuit of an electromagnet which actuates the printing stamp and feeds forward the inking ribbon thereof. The apparatus has been tried on the Posen Electric Street Railway, and has been found to be very satisfactory. The current is taken from the street mains, the pressure being reduced, by means of a resistance, to 200–250 volts. C. K. F.

2311. *Holden Meter.* **A. S. Garfield** and **J. A. Montpellier.** (Ind. Élect. 9. pp. 277–281, July 10, 1900; and Électricien, 20. pp. 81–86, Aug. 11, 1900.)—In this meter there is a wattmeter-system, consisting of a pair of fixed main-circuit coils C, and a pair of high-resistance shunt coils D mounted on a vertical arbor B so as to be capable of turning through an angle limited by stops *d* against the action of springs *b*, F, which also serve for conducting the



current to and from the coils D. The arbor B is also provided with an arm *e*, having a pawl which engages with a ratchet-wheel *f* on an independently mounted arbour B^1 so that when the circuit of the shunt-coils D is closed (which is effected once every one or two minutes by a clockwork mechanism), the arbor B will be rotated through a constant angle θ and an impulse given to the arbor B^1, the magnitude of this impulse being proportional to the electric energy in the circuit at that instant. This kinetic energy is taken up by weights *g*, adjustably mounted on arms on the arbor B^1 and is gradually converted into heat in a magnetic brake disc *h* turning between the poles of permanent magnets so that the angle through which the arbor B^1 turns, before it comes to rest, is a measure of the impulse imparted thereto by the arbor B. A retaining pawl is provided for preventing the arbor B^1 from being moved back when the arbor B is returned to its normal position by the springs *b*, F, after the shunt-coil circuit has been interrupted. By connecting the arbor B^1 to a counting train by means of the worm-gear shown, these angular rotations are integrated. The total current taken by the shunt coils of 1,000 of these meters (500 watt) is only from 2 to 3 amperes, and they will indicate accurately at 1 per cent. of the full load. C. K. F.

2312. *Meters for Three-phase Circuits.* **J. A. Möllinger.** (Elektrotechn. Zeitschr. 21. pp. 573–577, July 12; and 597–601, July 19, 1900.)—In the first part of the paper the author deduces various expressions for the power in a three-phase circuit, and considers the arrangements of the wattmeter connections suggested by them. Part 2 deals with the theory of watt-hour meters for three-phase circuits constructed on the Ferraris principle, the various methods of obtaining the necessary phase-relations between the currents in the main and shunt circuits being dealt with in detail. Part 3 contains a detailed description of a three-phase meter constructed on this principle. The moving part is very simple, consisting of two horizontal discs of aluminium mounted on a vertical spindle which carries a worm, geared with the counting mechanism. Each aluminium disc revolves between the poles of a ⊑-shaped shunt electromagnet, and in connection with each disc are two main coils, one on each side of the shunt magnet, with their axes normal to the disc. In the case of a meter intended for 3 × 10 amperes at 120 volts, the power taken by the shunt was about 5 watts, and the constant of the meter was found to vary by not more than 2 per cent. for various conditions of load, ranging from a balanced non-inductive load to an unbalanced inductive one having a power-factor of 0·304. Part 4 of the paper contains a description of a particularly simple form of meter intended for use on a balanced three-phase circuit. The meters are being manufactured by the Elektrizitäts-A.-G. vorm Schuckert and Co., of Nürnberg. A. H.

2313. *Power Supply by Small Motors.* **H. A. Mavor.** (Inst. Elect. Engin., Journ. 29. pp. 889–897; Discussion, pp. 897–899, July, 1900.)—On the basis of direct-current supply at 1d. per unit for power purposes, the author discusses the design of motors between ½ H.P. and 5 H.P., and emphasises the importance of high efficiency. If a ½ H.P. motor, costing £15, works for nine hours per day, the annual cost of energy is about £5, and the interest and depreciation charges, say 30s.; a larger motor of the same output, with 10 per cent. higher efficiency, and costing one-third more at first, would still cost no more per annum than the inferior motor. Small shunt-wound motors are costly, and in the author's opinion series winding is preferable, from both the maker's and the user's point of view. The variation of driving power required by most manufacturing machines between full and no load is very small, and series-wound motors can be designed to meet the conditions with very small variation of speed, and without risk of racing. Starting switches are at present far from satisfactory. The paper is accompanied by curves showing the comparative performances of small series and shunt-wound motors, from which it is seen that the series motors could neither run away, nor be burnt out by a temporary overload.

Discussion.—**W. A. Chamen** dealt with switch gear, and **W. H. Watkinson** referred to the difficulty of speed variation with series motors. A. H. A.

2314. *Switchboard Design.* **H. A. Bertram.** (Elektrotechn. Zeitschr. 21. pp. 667–674, Aug. 9, and 697–699, Aug. 16, 1900.)—This is a detailed description of the author's system of switchboard design. The main switches are actuated at a distance in a room at the back of the board through levers and rods, the switch arm being fitted with curved bars up which an arc can run and so break itself as in the Siemens and Halske lightning arrester. The top contacts of the switch fuses have a similar device. The measuring instruments have their faces flush with the marble panels. Details of interlocking gear, plug fuses, &c., are given, the article being illustrated by thirty figures. E. K. S.

GENERATORS, MOTORS, AND TRANSFORMERS.

2315. *Reluctance of the Teeth in a Slotted Armature.* **W. B. Hird.** (Inst. Elect. Engin., Journ. 29. pp. 933–941, July, 1900.)—In predetermining the characteristic of a dynamo with slotted armature, the calculation of the ampere turns required to pass a given number of lines through the teeth is difficult. The usual approximate methods err on the safe side by giving too high a value for the ampere turns. The author gives an approximate solution and curves that have been used in practice with satisfactory results. He also indicates a more accurate method of solving the problem, and mentions that an instrument has been contrived to simplify the calculations. He says that the reluctance of the teeth is of importance in calculating the effect of the cross-magnetising turns. The total flux entering a smooth core armature is not affected by the cross turns under the armature pole. When, however, there is iron in the gap, as, for example, the teeth of a slotted armature, then he proves mathematically that the total flux is not independent of the cross turns. The variation of the flux is appreciable when the teeth are worked at high inductions, and special allowance must be made for it in the case of large machines. A. R.

2316. *800-kw Steam Alternator by the Compagnie de Fives-Lille at the Paris Exhibition.* **J. Reyval.** (Écl. Électr. 24. pp. 241–247, Aug. 18, 1900.)—A very full description of a three-phase alternator coupled to a compound horizontal engine, the output being 800 kw. (with a power factor of 0·7) at 2,200 volts, the current per phase being 210 amperes with a frequency of 50 periods.

Engine.	
High pressure cylinder	700 mm. dia.
Low pressure cylinder	1,300 ,,
Stroke	1,400 ,,
Variation in one revolution	$\frac{1}{250}$
Steam pressure	10 kg. per sq. cm.
Alternator.	
Diameter of armature core	6 m.
Length of armature core	70 cm.
Diameter of wire	3·9 mm.
Total resistance of each armature winding	0·0778 ohms.
Loss in armature winding	1·3 per cent.
Weight of armature ring complete	33,500 kg.
Number of poles	76.
Air-gap	7 mm.
Number of turns on each pole	155.
Diameter of wire	4·7 mm.
Total resistance	3·06 ohms.
Weight of field-magnet system with flywheel	35,000 kg.

The article is illustrated by ten figures and a sheet of curves. E. K. S.

2317. *Standardisation in Specifying the Performance of Generators.* **G. Dettmar.** (Elektrotechn. Zeitschr. 21. pp. 727–733, Aug. 30, 1900. Paper read before the 8th Jahresversammlung des Verbandes Deutscher Elek-

trotechniker in Kiel.)—The author draws attention to the difficulties which frequently arise in the case of disputes on account of the absence of definite standards with respect to the performance of generators. Inquiries addressed to manufacturers show that the need of setting up definite standards is widely felt. Dealing with the question of output, the author points out that in the case of motors intended for cranes, railways, rolls, &c., and in fact wherever the power is liable to great fluctuations, the term "output" should be more precisely defined. Another uncertainty in connection with this term arises with respect to the time during which the machine is supposed to give its rated output; in some cases five hours is assumed to be a sufficient test, in others six, eight, ten, or more. The author next considers the question of heating, and emphasises the importance of specifying the method by which the rise of temperature is to be determined. The difference between the thermometer and the increase of resistance methods may amount to as much as 40 per cent. for armatures, and 60 per cent. for field magnets. He gives an account of some experiments carried out with a view to testing the highest permissible temperature for cotton-covered wires, and arrives at the conclusion that for moving coils the maximum should never exceed 90° C., the cotton becoming brown and brittle if heated beyond this limit; for fixed coils a slightly higher maximum might be allowed. From this the author concludes that the highest rise of surface temperature as measured by a thermometer should be fixed at from 32° to 42° C. for rotating coils, and at from 35° to 45° for stationary coils. The concluding section of the paper deals with the methods of determining the efficiency and analysing the losses in a generator. In specifying the efficiency regard must be had to the material of the brushes, a difference of standard being introduced on account of the much higher loss which occurs with carbon brushes. A. H.

2318. *Farcot Two-phase Steam Alternator at the Paris Exhibition.* **C. F. Guilbert.** (Écl. Électr. 24. pp. 41–49, July 14, 1900; also Ind. Élect. 9. pp. 273–277, July 10, 1900.)—Description of a two-phase generator set at the Paris Exhibition. Both the alternator and the horizontal engine which drives it were built at the Farcot Works at Saint Ouen. The engine is remarkable in that, although working with high-pressure steam at $\frac{3}{10}$ cut off and 78½ revs., it indicates 1,600 H.P. with only one cylinder [see Abstract No. 2302, 1900)].

The alternator is of the inductor type, and is specially fitted with Hutin and Leblanc "amortisseurs"; it is said that these, together with the heavy mass of the inductor wheel, give a sufficiently even turning moment for running in parallel. The alternator gives 880 kw., with a power factor of 0·85, the frequency being 42 cycles per second, which requires 64 poles (32 on each inductor ring).

The armature conductors are 3·5 mm. × 38 mm., or 133 sq. mm. area, and the resistance of each half is 0·113 ohm when warm. The external diameter of the armature is 6·8 metres, and the internal diameter 5·515 metres, the weight being 60,000 kg. The outside diameter of the inductor wheel is 5·5 metres, its weight being 50,000 kg. The single exciting coil consists of 460 turns of copper wire, 7·5 mm. diameter, having a resistance of 3½ ohms.

The "amortisseur" coils are formed of copper 28 mm. in diameter, there being five conductors opposite each alternate slot in the armature core.

The exciter is direct driven, has six poles, and gives 60 amps. at 220 volts; diameter of armature 750 mm., and length 450 mm.

The article is an important one, and includes five good illustrations.

E. K. S.

2319. *Dynamos and Motors.* **F. Niethammer.** (Elektrotechn. Zeitschr. 21. pp. 528–531, June 28; and 549–551, July 5, 1900.)—This paper contains notes on the following subjects: (1) The theory of rotary converters, more especially in connection with their heating and armature reaction; (2) Armature reaction in dynamos and alternators; (3) The determination of the drop in polyphase generators when magnetic leakage is taken into account; (4) The losses in the pole-pieces of dynamos; (5) Sparking in dynamos with toothed-core armatures, some formulæ being given which are intended tc serve as criteria regarding the quality of the machine from the sparking point of view; (6) Calculation of the inductance of an armature coil from the shape of the slots in which it is embedded; (7) Predetermination of maximum rise of temperature of field and armature coils. In connection with this latter subject the author gives the following formula, which is said to be equally applicable to stationary coils, armatures, and commutators:—

$$t = \frac{w}{S(1 + 0{\cdot}3\sqrt{v})}C(1 + 0{\cdot}2d),$$

where t = rise of temperature, in degrees C.; w = watts dissipated; S = area of radiating surface, in sq. cms.; v = peripheral velocity, in metres per sec.; d = depth of winding, in cms. C is a constant whose value lies between 250 and 350. For armatures d may be put = 0, and for commutators, in addition to putting $d = 0$, $\frac{C}{2}$ must be used instead of C. Similarly, in the case of the rotors of induction motors, on account of the practical absence of hysteresis and eddy-current losses in the core, $\frac{C}{2}$ must be used instead of C. In applying this formula, end surfaces and inner surfaces must only be credited with $\frac{1}{3}$ to $\frac{1}{4}$ of their actual values. A. H.

2320. *Induction Motors with Large Starting Torque.* **M. Déri.** (Ind. Élect. 9. pp. 324–327, Aug. 10, 1900.)—The principle on which the construction of such motors depends has already been noticed in a previous Abstract [see Abstract No. 1285 (1898)]. The present paper contains an illustrated description of a motor of this type exhibited in the Austrian section of the Paris Exhibition. It is stated that a starting torque equal to 2·6 times the normal running torque may be obtained with a current not exceeding 1·6 times the normal current taken by the motor. A. H.

2321. *Induction Motor Diagrams.* **R. Goldschmidt.** (Elektrotechn. Zeitschr. 21. pp. 693–697, Aug. 16, 1900.)—The total power given to the rotor of an induction motor may be supposed to be dissipated in an imaginary equivalent resistance $r_2' = r_2/\sigma$, where r_2 = resistance of rotor, and σ = slip. The power transformed into mechanical power will then correspond to that dissipated in a resistance $r_2\left(\frac{1}{\sigma} - 1\right)$. The induction motor may now be replaced by a transformer whose secondary contains a resistance r_2/σ; and this has the same effect on the primary as a resistance of amount $\frac{r_2}{\sigma} \cdot a^2$, where $a = \frac{\text{primary turns}}{\text{secondary turns}}$, placed in the primary. If further, L_1 = leakage inductance of primary, L_2 = leakage inductance of secondary, r_1 = resistance of primary, $L = L_1 + a^2L_2$, $r = r_1 + a^2r_2$, then the transformer may be replaced by a simple inductance coil of resistance $r + a^2r_2\left(\frac{1}{\sigma} - 1\right)$, and inductance L.

In order to take into account the magnetising current, we may suppose an auxiliary inductance coil of resistance r_0 and inductance L_0 joined in parallel with the main inductance coil[1] (fig. 1). Making use of the transformation just explained, the author establishes the following method of studying the behaviour of an induction motor. The short-circuited rotor standing still, the P.D., V, the current i, and power w are measured (in most cases it will be necessary to carry out this measurement at a P.D. below the normal, and assume that i is proportional to the P.D.). Further, the current i_0 and power w_0 are measured when the motor is running light. The data so obtained are used for constructing the diagram shown in fig. 2 as follows: Draw a right-angled triangle, ADC, in which $AC = i$, and $CD = \frac{w}{V\sqrt{3}}$ = the power-component of i. Lay off $DF = \frac{3i_1^2 r_1}{V\sqrt{3}}$, where $i_1 = i - \frac{i_0}{2}$, and join FA. From C draw CE at right angles to AC, and on AE describe a semicircle. From A

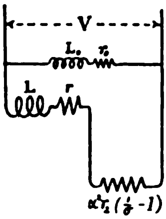


FIG. 1

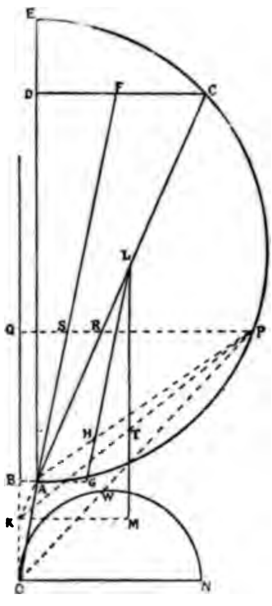


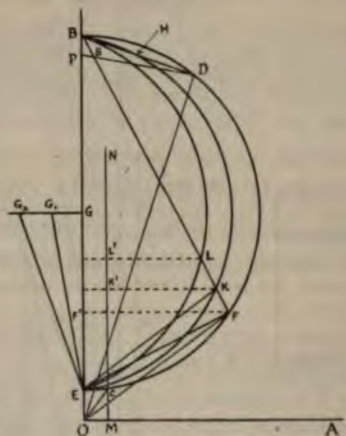
FIG. 2

draw $AO = i_0$ in such a direction as to make AB (where AB is perpendicular to AE) $= \frac{w_0}{V\sqrt{3}}$. Draw $ON = 1$ at right angles to OB, and on ON describe a semicircle. From any convenient point L in AC draw LG parallel to FA. Next produce CA until it intersects BO in K, and construct the right-angled triangle KLM. If we take any point P on the large semicircle, then OP = primary current; OW = power factor; PQ = total power absorbed by motor; PS = total power given to rotor (to a suitable scale PS will also represent the torque); GH $= \sigma =$ slip, if GL be taken to represent a slip of 100 per cent., and LT = equals electrical efficiency of motor, if LM be taken

[1] This would make the magnetising current constant, which is known not to be the case. But, as the author points out, the necessary correction may be applied after the value of the main current has been determined.

as 100 per cent. By completing the circle on AE the diagram may be extended to the case of an induction generator. In the second part of the paper the author applies a similar method to the study of a single-phase motor. A. H.

2322. *Testing Induction Motors.* **Heyland.** (Écl. Électr. 24. pp. 17–26, July 7; and 49–59, July 14, 1900.)—The introductory portion of the paper is devoted to a general account of the theory of induction motors; this is followed by a description of the author's diagram (explained below) for such motors. By means of such a diagram the behaviour of any given motor may be completely predetermined. The use of the diagram is exemplified by a number of actual tests carried out on various types of motors. In order to obtain the data necessary for constructing the diagram, the following measurements are required: (1) The current and power taken by the motor when running light; (2) The short-circuit current and power when the rotor is



prevented from turning; (3) The resistance per phase of the stator winding. The diagram is then constructed as follows: Take two lines, OA and OB (see fig.), at right angles from each other. From O lay off a vector OC to represent the primary current when the motor is running light, the angle AOC being such that cos AOC is the power-factor. Next lay off a vector OD to represent the primary short-circuit current (rotor at rest), cos AOD being the corresponding power-factor. Through the points C and D draw a circle having its centre G on the line OB. Then the extremity of the primary current vector travels along this circle as the load is varied. Let OB be taken to represent the P.D. of the supply mains. Then BD will represent, to the same scale, the total resistance drop on short-circuit. Let r_p be the resistance of the stator windings per phase, and i_s the short-circuit current. From D lay off $DH = \sqrt{3} \times r_p i_s$, and draw a circle through the points B, H, E, having its centre at G_1. Draw a third circle passing through B and E, and touching BD at B; let G_2 be the centre of this circle. Next from D draw DP, making the angle DPB equal to the angle in the segment EKB of the circle which has its centre at G_1. Lastly, through C draw a line MN parallel to OB. The diagram may now be used as follows for the purpose of studying the behaviour of the motor under varying conditions of load: Take any value of the primary current, say OF. Then cos AOF gives the corresponding power-

factor. Join BF, and from F, K, and L draw perpendiculars to OB. Then FF′ represents the total power supplied to the motor (to the same scale as that to which OM represents the power taken when running light); KK′ represents the useful torque; and LL′ the brake-power; all corresponding to the current OF. Further, PS gives the percentage slip (PD corresponding to a slip of 100 per cent.). The overload capacity of the motor, its starting torque, &c., are easily determined by means of the diagram. The concluding portion of the paper deals with single-phase motors, the action of such motors being briefly discussed. The author points out that single-phase motors require careful designing, and that it would be a great mistake to suppose that a good polyphase motor would also make a good single-phase one if allowed to run on one phase only. A. H.

REFERENCES.

2323. *Design of Induction Motors.* **J. Fischer-Hinnen.** (Zeitschr. Elektrotechn., Wien, 18. pp. 346–348, July 15; 357–364, July 22; 370–375, July 29; 381–388, Aug. 5; and 397–403, Aug. 12, 1900.)—A series of articles relating to the design of induction motors, and consisting mainly of a useful collection of tables and formulæ. A. H.

2324. *Distribution of Induction over Pole-face in Dynamos.* **C. Westphal.** (Elektrotechn. Zeitschr. 21. pp. 747–749, Sept. 6, 1900.)—By considering the magnetomotive forces and reluctances of the various parts of the magnetic circuit, the author constructs curves, similar to those given in Abstract No. 1744 (1900), giving the field distribution around the armature circumference (1) when the machine is running light; (2) when it is loaded, the brushes not having any lead; and (3) the brushes having a lead. The results obtained are applied to find (*a*) the drop of potential at full load when the excitation is kept constant; (*b*) the increase of excitation required to maintain the P.D. constant at full load. A. H.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

2325. *Aluminium Wires and Polyphase Transmission.* **F. A. C. Perrine** and **F. G. Baum.** (Amer. Inst. Elect. Engin., Trans. 17. pp. 391–423, June and July, 1900.)—In some results previously published by one of the writers there were several misprints [see Abstract No. 318 (1900)]; these are now corrected in this paper. Full details are given of the 43-mile power transmission line of the Standard Electric Company of California. A temporary two-phase arrangement is employed so as to utilise the present machinery of the Company, but the conversion to three-phase will take place shortly. Each pole has three cross arms whose ends form a hexagon. The insulators are of glass, of the flat-topped triple petticoat type, and are supported on long eucalyptus pins. An aluminium strand ¾ inch in diameter will be used, and the total weight of aluminium will be nearly 450 tons. A. E. Kennelly reports as follows on the aluminium wire at present in use :—

Diameter	293·9 mils.
Weight per mile	419·4 lbs.
Resistance per mil. foot at 25° C.	17·6 ohms.
Resistance per mile at 25° C.	1·0077 ohms.
Conductivity compared with copper	59·9 per cent. by dimension.
Tensile strength of wire	1,549 lbs.
No. of twists in 6 inches for fracture	17·9.
Tensile strength per square inch	32,898.

He compares it with copper as follows :—

Diameter for the same conductivity	1·27 times copper.
Area " " "	1·64 " "
Tensile strength " "	0·629 " "
Weight " "	0·501 " "

In erecting aluminium lines it has to be remembered that it is easy to permanently stretch the wires and that they have a large temperature coefficient. The results of experiments made by the Pittsburg Reduction Company and the authors on the sag of spans of aluminium wire at various temperatures and tensions are given in tabular form. The instructions to the line foreman as to the methods of jointing, spiralling the wires, &c., are also published. The breaks of the wires on the Seattle line are stated to have been due to contraction in the cold weather, insufficient sag having been allowed.

The writers also give experimental data and mathematical calculations of the capacity, self and mutual inductance, ohmic resistance and insulation resistance of transmission lines. In addition to the line mentioned above they experimented on an aluminium line 62 miles in length. They prove that the line capacity of an overhead three-phase system of wires may be considered as that of three condensers connected between the wires in a star and not a mesh pattern. If the capacity be considered as mesh connected, then the charging current in each wire would be $\sqrt{3}$ times the charging current

of a single-phase line; but if it were star connected then the charging current would only be $\frac{2}{\sqrt{3}}$ times that of a single-phase line. By experiment they found the latter to be the correct supposition.

Valuable formulæ are proved by original methods for the capacity of line wires. If the centres of the wires are at the corners of an equilateral triangle whose side is d, and if r be the radius of the wires whose length is L miles, then we can calculate the charging current by supposing three condensers each of capacity K where—

$$K = \frac{0{\cdot}0388L}{\log_{10} \frac{d}{r}} \text{ microfarads}$$

connected starwise between the three mains. The radius of the wires is supposed to be small compared to their distance apart. The influence of the earth on the capacity can in general be neglected. The self-inductance of one wire of the three wires being S, then in calculating the inductive drop in a loop we can assume that the self-inductance of the two wires is $S\sqrt{3}$ where—

$$S\sqrt{3} = 0{\cdot}000558 \left[2{\cdot}303 \log \frac{d}{r} + 0{\cdot}25\right] L, \text{ henries.}$$

The effect of the charging current on the regulation of the system is discussed mathematically, and it is stated that the method given yields results as accurate as could be obtained by actual measurements with the best instruments.

The paper concludes by describing some transmission line troubles. At the receiving end of the two-phase forty-mile line there are in operation two shunt-wound synchronous motors of 50 and 100 kw. respectively. Their working at first was very unsatisfactory. At no-load the current they took was nearly equal to that at full-load, and they were very unstable, easily falling out of synchronism. This was not due to "hunting," as copper bridges put between the poles of one of the motors did not improve its running. The large no-load current was thought to be due to the difference in wave shape between generator and motor E.M.F.'s. By neutralising the capacity current by means of inductive coils the 50 kw. motor at no-load only took 8 amperes per phase instead of 13, and the variation in volts at the receiving station at different loads was reduced from 10 per cent. to 3 per cent., and nearly all this 3 per cent. was traced to the change in speed of the water-wheels.

A. R.

2326. *Distribution of Electricity.* **G. Wilkinson.** (Elect. Engin. 26. pp. 47–50; Discussion, p. 50, July 13, 1900. Paper read before the Municipal Electrical Association, June 22.)—The author emphasises the importance of reliability in the distributing system, and discusses the various methods of distribution in use, with the purposes for which they are suitable. Service boxes for three-core cables cost only half as much as for triple concentric cables, while the frequent cuttings necessary with the latter impair the conductance of the mains. Paper-insulated concentric mains with the outer earthed are the best for high pressures. Too many types of joint-box are in use. A disconnecting-box should be fixed at every street corner; but fuses should not be used. In mechanical joints the outers of concentric cables are best clamped between two flat metal discs, made in halves; the boxes ought also to be in halves, to avoid the necessity of cutting the cable. The connections should be enclosed in a light box, to keep the waterproof

compound off them. A good high-tension joint-box is that in which the ends of the cables are brought in vertically through the bottom; in this case the "inner" connecting-bar may be made to serve as a switch if required. These boxes cost less than £5 5s. each complete, with outer box and labour, whilst the ordinary forms cost at least £7 7s. 6d.

Discussion.—**C. H. Wordingham** said that in Manchester bare copper mains were used for outlying districts where possible. **W. A. Chamen** preferred earthenware troughing for the solid system. A. H. A.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

2327. *Chicago Generating Stations.* (Elect. World and Engineer, 35. pp. 729-741, May 19, 1900.)—The stations worked by companies supply 17,600 arc lamps and 512,000 incandescent lamps, while 870 isolated plants supply 13,800 arcs and 372,000 incandescents; the municipality also owns four stations running 3,500 arcs for street lighting.

The Edison Company feeds current into its 230-volt network at six stations, which are connected by three-phase, 25-cycle, 4,500-volt mains, double-current generators and rotary converters being employed. It is intended to concentrate the generating plant mainly in two or three of the stations most conveniently situated as regards coal and water supply, and to use the others as converting substations, the steam plant in the latter being used as a reserve for times of heavy load. Double-current generators have proved very advantageous, and a 2,500 kw. machine of this type is to be added at the chief station.

One storage-battery substation has a capacity of 22,400 amperes for one hour, or 44,800 ampere-hours at an eight-hour rate of discharge. Boosters are preferably driven by synchronous motors wound for 4,500 volts. Many commercial arcs are being changed over from series circuit to the low-pressure constant potential mains. The rotary converters have from 4 to 10 poles; while the double-current dynamos have 20 or more, with the same number of sets of brushes. Some of the latter machines have face commutators.

The Commonwealth Company is constructing a model polyphase station to supply all loads within a district of 63 square miles, comprising the southern part of the town. The three-phase, 60-cycle generators will give 2,300 volts between the junction of the Y and each outer terminal. A fourth wire will be brought from the junction, and each of the 2,300 volt single-phase feeders will be connected between this fourth wire and one of the outer terminals, the feeders being divided in such a way as to balance the load. Each feeder can be independently regulated, and can be switched on to any of the three phases. Three-phase feeders are to be run for motors. The two-wire lighting feeders run to transformers converting down to 2 × 115-volt three-wire distributors.

The three-phase feeders supply transformers with Y-connected primaries and delta-connected secondaries, giving 230 volts between mains. All instruments on the switchboard will be of the horizontal edgewise type, and they will be supplied from instrument transformers with earthed secondary. Thus no high pressures will be taken to the operating-board, which comprises the upper part of the switchboard and is reached by a gallery. The lower part of the switchboard consists of the 'bus-bar panels carrying those switches and other apparatus which do not require frequent handling. The 'bus-bars will

be treated with fireproof paint, and mounted on glass insulators. All cables about the board are paper-insulated and lead-covered.

The generators will be General Electric revolving field machines mounted between the cranks of Southwark vertical cross-compound engines, with which jet condensers will be used. The Babcock and Wilcox 500-H.P. boilers have superheating coils, placed so as to intercept the hot gases after their first crossing of the water-tubes. There is one generating unit of 400 kw., the others being 1,000 kw. each. The ultimate possible capacity of the station, of which sectional drawings are given, is 10,000 H.P.

The municipal plants are four in number and consist mostly of vertical marine-type cross-compound condensing engines of 500 H.P. to 800 H.P. connected through clutch couplings to line shafts, to which are belted Western Electric and Brush series arc dynamos of 100- to 160-light sizes. There are 270 miles of streets lighted by electricity, 713 by gas, and 327 by gasolene. The corresponding costs of lighting per mile are $567, $785, and $442. The cost per lamp (without any interest charges, however) is $55·9 per year, or $0·0138 per hour. W. H. E.

2328. *New York Electricity Works.* (Elect. World and Engineer, 35. pp. 931–934, June 23, 1900.)—System: Two-phase alternating current transformed at substations from 3,000 to 105 volts. The boiler-room contains twelve 600-H.P. boilers of the upright water-tube type, generating at 150 lbs. per square inch. Each boiler contains 588 tubes 11 feet long and 3 inches diameter. The feed-water is heated by two heaters using exhaust steam, which raise the temperature to about 200°. Coal is dumped into a filler below the street level, and is carried to the bunkers by an endless chain of buckets. From the hoppers in the bottom of the bunker it is shot to the different boilers. The engine-room contains eight "Columbian steepled compound" engines by the Westinghouse Machine Company of 1,200 H.P. each at 200 r.p.m. The cylinders are in tandem and measure 21½ inches and 37 inches, with stroke of 22 inches. Three 100-H.P. Westinghouse single-action tandem compound engines drive the exciters. Close to each engine is a combined separator and receiver containing eighteen times the volume of steam required for one stroke; these maintain a uniform flow of steam in the pipes. Below the engine-room are two Worthington jet condensers of 5,000 H.P. each. Each large engine drives directly a 750 kw. two-phase, 3,000 volt Westinghouse generator. The armature is mounted on the engine shaft, the generator having but one bearing. Each small engine drives through a flexible coupling a 75 kw. Westinghouse exciter. Sixteen feeders supply transformers usually placed under the pavement. The main switches are of the Westinghouse high-tension plunger type; in these each circuit is broken at two points and each break takes place in a small enclosed air chamber formed by a porcelain tube. A small vent produces a lateral draught which tends to extinguish the arc. In the old station three new Westinghouse generators of 400 kw. each are run by three old Corliss engines in parallel with the new station, but these will shortly be replaced by four Westinghouse-Parsons steam turbines of 2,500 H.P. each, connected directly to generators of 1,500 kw. each running at 1,200 r.p.m. At present current is supplied for about 400,000 8-c.p. lamps, 2,000 arc lamps, and 3,000 H.P. of Westinghouse induction motors. G. H. B.

2329. *Gloucester Electricity Works.* (Elect. Engin. 26 pp. 78–85, July 20, 1900.)—System: Continuous current, three-wire, with batteries. The boiler-

room contains three Lancashire boilers, 30 feet by 8 feet, of steel plate $\frac{13}{16}$ inch thick, by Yates & Thom; working pressure 160 lbs. There is on order to Tinkers Limited, one Lancashire boiler, 30 feet by 8 ft. 6 in., capable of evaporating 8,000 lbs. of water per hour, with plates $\frac{7}{8}$ inch thick, and to Heenan & Froude, a twin-cell refuse-destructor having a capacity of fifty tons per twenty-four hours. Above the cells will be the combustion chamber, and above this a water-tube boiler having 1,300 feet of heating surface. The feed-water is heated by a feed-heater and a Green's economiser of ninety-six tubes. Coal is fired by Proctor's mechanical stokers, driven by a 5 kw. motor. The engine-room contains two engines; the larger is a triple-expansion engine with one high and two intermediate cylinders placed above three low-pressure cylinders, giving 500 I.H.P. at 350 r.p.m.; the smaller is a two-crank compound engine with two cylinders, giving 250 I.H.P. at 380 r.p.m. Two jet condensers by the Blake and Knowles Steam Pump Company can each condense 10,000 lbs. of steam per hour at a vacuum of 26 inches. There is on order a Willans central-valve triple-expansion engine of 500 I.H.P. at 320 r.p.m. The larger engine drives directly two Silvertown dynamos of an aggregate output of 300 kw. at 440–500 volts. They have drum-bar armatures and shunt-wound magnets. The smaller engine drives directly two similar dynamos of 75 kw. each at 220–250 volts. There are on order two Mather & Platt dynamos, giving each 680 amperes at 220–250 volts at 320 r.p.m. A 15 kw. booster takes current at 220–250 volts, and supplies 100 amperes at 20–150 volts at 780 r.p.m. Five feeders of 0·4 square inch section and one of 0·25 square inches supply the private lighting; they consist of triple concentric lead-sheathed cables, laid by the Callender Company in cast-iron troughs, which are filled with bitumen. Their total length is $3\frac{3}{4}$ miles. The public arc lamps are supplied by one $\frac{7}{16}$ single lead-sheathed cable laid direct in the ground. A three-core $\frac{7}{16}$ pilot cable runs with each feeder. The distributors are similar to the feeders and have a total length of $12\frac{1}{4}$ miles. The switchboard is by Crompton & Co. The middle wire is connected to earth through a recording ammeter and automatic switch which falls at 10 amperes and puts a resistance in circuit. The station is equipped with two batteries of E.P.S. accumulators, type K.W.S., each battery contains 140 cells and has a discharge capacity of 210 amperes for two hours, 168 for $3\frac{1}{2}$ hours, 112 for seven hours, or 80 for ten hours. There are thirty plates in a cell, contained in a lead-lined wood box. The price charged is 7d. and 2d. per unit for lighting and $4\frac{1}{2}$d. and $1\frac{1}{2}$d. per unit for power, the higher rate being charged for any number of units up to the equivalent of 100 hours' use per quarter of the maximum demand. G. H. B.

2330. *Destructor and Electric Power Station at St. Helens.* **J. S. Highfield.** (Elect. Rev. 47. p. 7, July 6, 1900.)—The installation includes two destructor furnaces, each having two cells on the Beaman and Deas principle, with closed ashpits, forced draught being supplied underneath the hearths from a centrifugal blower driven by an electric motor, a Babcock-Wilcox boiler having 1,740 square feet of heating surface with a superheater, and a Green's economiser having ninety-six tubes. The gases from each furnace reach the boiler through a combustion chamber and afterwards pass through the economiser. The steam, with about 100° F. of superheat, passes to four Willans & Robinson three-crank compound condensing engines with direct coupled generators of a total capacity of 600 kw. A Wheeler condenser and a Klein cooling tower form the condensing plant. The results obtained in ordinary work, day by day in May last, are as follows :—

		Tons.	Cwts.
Average weight of refuse burnt per week		143	18
„ „	clinker and ash per week	40	8
„ „	mortar made	15	2
„ „	refuse per shift of nine hours	13	1½

Average units used to work fan per ton, 9.
„ generated from steam per week, 7,062.
„ „ per ton burnt, 50.
Average wages per ton burnt, 1s. 1¾d.

[See also Abstract No. 1797 (1899).] F. J. R.

2331. *Automatic Coal-handling Plant at the Leeds Electric Power Station.* (Mech. Eng. 6. pp. 44–46, July 14, 1900.)—The distribution of coal to large batteries of boilers without manual labour is an important matter, and the appliances introduced to this end in America are being adopted in this country. This article describes with illustrations the arrangements for handling by machinery all the coal required by eight Lancashire boilers, 30 feet long by 8 ft. 6 in. diameter, and one Babcock-Wilcox boiler, placed in two groups, separated by the space required by an economiser and a chimney—the boiler-house being about 177 feet long by 62 feet wide, with the coal stores opposite the boiler fronts, but not quite parallel with the boiler-house proper. For details the article must be consulted. F. J. R.

2332. *Swansea Electric Tramways.* (Electrician, 45. pp. 433–436, July 13, 1900.)—This system has been equipped by the British Electric Traction Company. The route at present served is about 5½ miles. The generating station is at St. Helens, which is at one end of the system, but will be about central when the company has converted the Mumbles Railway, which is at present worked by steam. The boiler-house contains two Babcock-Wilcox boilers, each capable of evaporating 7,000 lbs. of water per hour at 150 lbs. steam pressure from a feed temperature of 150° F. A superheater adds 100° of superheat. The condenser is of the Wheeler horizontal surface type of 700 square feet area. The engine-room contains at present two large sets consisting of Ball & Wood engines, having cylinders 15½ inches and 31 inches diameter, and 16-inch stroke, of 350 I.H.P., coupled to Westinghouse 8-pole dynamos, over-compounded to compensate for feeder-drop and capable of meeting a load of 365 amperes at 550 volts. There is also a smaller 50-H.P. Alley-Maclellan engine coupled to a motor-generator and the usual negative boosters, giving 4¾ kw. at 950 r.p.m. There are forty-one cars in all equipped with the usual 25-H.P. motors, &c. E. K. S.

2333. *Glasgow Electric Tramways.* (Tram. Rly. World, 19. pp. 343–356, August, 1900.)—The station is divided into three sections—boiler-room, 244 ft. × 84 ft. × 70. ft. high ; engine-room, 244 ft. × 75 ft. × 64 ft. high ; and auxiliary plant-room, 244 ft. × 40 ft. × 52 ft. high. The two chimney-stacks are 263 ft. high and 16 ft. internal diameter. The boiler-room contains sixteen Babcock & Wilcox boilers in eight batteries of two each, working at a pressure of 160 lbs., each boiler being capable of producing 20,000 lbs. of steam per hour. The feed-water is heated by means of two economisers supplied by the Clay Cross Company, each capable of heating 12,000 gallons of water per hour from 90° to 160° F. Coal is stored over the boilers in bunkers holding 2,400 tons, and is fired by Babcock & Wilcox type of mechanical stoker, driven through shafting by two 30-H.P. motors. The

mechanical bucket-conveyer can handle fifty tons per hour at 45 ft. per minute. The engine-room contains four engines, each coupled direct to a three-phase generator, the maximum power being about 5,000 I.H.P. at a speed of 75 r.p.m. They are of the vertical compound three-cylinder condensing type, and fitted with special Corliss valve gear. Two of these are by the Allis Company, and the remaining two by Musgrave & Sons. In the Allis engine the high-pressure cylinder is 42 in. diameter, and each of the low-pressure cylinders 62 in. diameter, with a stroke of 5 ft. The engine weighs 700 tons, of which the flywheel, 24 ft. in diameter, accounts for 98 tons. The governors are such that the speed is not to vary more than 1½ per cent. above or below the normal speed under any fluctuations from no load to maximum. The angular velocity is not to vary more than ⅕ per cent. during any revolution at any constant load. In addition to the automatic control governor there is also an emergency governor designed to cut off the entire supply of steam should the speed of the engine increase by more than 5 per cent. above the normal. The guaranteed steam consumption is 14 lbs. per B.H.P. hour. The generators are supplied by the British Thomson-Houston Company, and have an output of 2,500 kw. at 6,500 volts and 25 periods. The weight of each generator is 90 tons, of which the revolving field-magnet system accounts for 38 tons. The guaranteed efficiency is 96, 95, and 93½ at full, three-quarter, and half load respectively. The exciters are 6-pole 50 kw., giving 100 volts, and driven by Allen high-speed engines. The feeders are three-core cables, their area in some cases being 0·15 and in others 0·1 sq. in. They are paper-insulated, with a lead covering of $\frac{3}{16}$ in. thickness, and are carried through the wall of the power-house into a tunnel, and from thence to each of the five substations. The substations contain 200 kw. static Westinghouse oil-cooled transformers, stepping down from 6,500 to 310, 330, or 350 volts, according to the points at which the coils may be tapped. The efficiency is 97½ and 97 per cent. at full and half load. Three of these transformers supply each of the 500 kw. rotary converters, over-compounded from 500 to 550 volts. They are 6-pole machines, running at 500 r.p.m., and were supplied by the Westinghouse Company. The efficiencies at full, three-quarter, and half load are 95, 94, and 92½ per cent. respectively. Each rotary has a three-phase motor connected at one end of the shaft for the purpose of starting and bringing the rotary into synchronism. At the opposite end of the shaft is a continuous current booster, designed for dealing with part of the return current from the tramway tracks so as to minimise and control the drop in the rails. All the cables, high and low tension, were supplied by the National Conduit and Cable Company of New York, and it may be mentioned that there is in all approximately 3,000,000 ft. of pipe in the cableways. The contractors for the permanent way laid about one-third of the ducts, consisting of earthenware pipes, the National Company laying the remainder, consisting of their cement-lined tubes. The track is equipped on the overhead system, the trolley wires being supported by span wire fixed to the walls of buildings where possible, and otherwise from post to post across the street. The trolley wire is of hard-drawn copper, No. 00 B. & S., 0·365 in. diameter. The rails are of the steel grooved girder type, weighing 98 lbs. per yard, with groove 1¼ in. by 1¼ in. so as to take the flanges of ordinary railway waggons, the gauge being 4 ft. 7¾ in. The rails are in lengths of 60 ft. each. The fishplates are 31 in. long and weigh 74 lbs. per pair, and the joints are bonded with two long No. 0000 B. & S. solid copper bonds with Daniell terminals through the web; there are also two similar bonds through the base of each rail, which is

laid on a 6-in. bed of concrete. The cars are carried on Brill single trucks, equipped with two motors with series parallel controllers. Most of the cars are being built by the Corporation themselves. *Drawings:* The article is illustrated by seventeen line drawings and a route map of the district served.
E. K. S.

2334. *Southport Lighting and Traction System.* (Electrician, 45. pp. 510–512, July 27, and 546–550, Aug. 3, 1900.)—System : For lighting, single-phase alternating current at 2,000 volts with substations transforming to 100 and 200 volts, the latter for outlying districts ; for arc-lighting, Ferranti rectifiers. For traction, continuous current at 500–550 volts. The boiler-room contains six Lancashire boilers, each 28 feet by 7 feet ; grate area, 66 square feet. During tests, with a mean pressure 132 lbs. per square inch, full-load consumption was 15 lbs. of steam and 1·8 lbs. of coal per I.H.P. hour ; at three-quarters load and half load corresponding figures were 15·3 and 1·86 lbs., and 16 and 1·97 lbs. Musgrave & Co. are putting in three Lancashire boilers, 30 ft. by 8 ft. 6 in., rated at 600 H.P. in aggregate, with superheaters for 120°. The feed-water is heated by one Roberts economiser of 288 tubes ; one of 360 tubes is to be added. Coal is stored in bunkers above the boiler-room floor, and is fired by hand. The engine-room contains, for lighting, two cross-compound Corliss condensing engines of 250 I.H.P. each, erected in 1895 and 1896 ; one 500 I.H.P., erected in 1897 ; and one vertical three-crank tandem-compound engine of 600 kw., with piston gear, running at 214 r.p.m. —all by Musgrave & Co. The particulars of the 1897 engine are : Cylinder diameters, $17\frac{1}{32}$ and $33\frac{1}{64}$ inch, not jacketed ; stroke, 3 ft. 6 in. During full-load test the speed was 96 revs., mean piston speed 672 feet, mean I.H.P. 490·3, mean vacuum in condenser 27 inches. The 600 kw. engine has three separate jet condensers. For traction there is one Belliss E.C. No. 12, 375 B.H.P. engine, working at 130 lbs. with 100° of superheat, running at 350 revs. Guaranteed steam consumption 28 lbs. per kw. hour. For lighting, the 1895, 1896, and 1897 engines drive directly three Ferranti alternators of the revolving field type, with armatures connected in series and lap-wound. The 600 kw. engine drives directly a Ferranti alternator of the revolving armature type, the armature being connected in two parallel halves. It gives 286 amperes at 2,100 volts, running at 214 r.p.m. Frequency 50 revs. Two Cowan's boosters will raise the pressure by 150 volts at 100 amperes. Two Ferranti rectifiers are each capable of supplying forty-two 15-ampere arcs. The Parker exciters are driven by rope gearing off shafts. For traction, the engine drives directly one 200 kw. compound-wound Peebles dynamo, 4 pole, with drum armature. Pressure, 500–550 volts ; efficiency, 89 per cent. at full load. A second set is about to be laid down. Feeders : For lighting, no details of feeders are given. For traction, one feeder of 0·4 square inch section (three more are to be laid) and two insulated rail feeders of 0·75 square inch section for the centre of the system are laid. The feeders are laid on the Callender solid system in U-shaped stoneware troughs, filled with compound and covered with a stoneware brick. At the feeding-points vulcanised indiarubber wire is employed from the section boxes to the trolley line. The track is equipped on the overhead trolley system ; steel tubular poles carry, by means of brackets, two trolley wires on insulators held by a short span wire below the bracket arm. The two trolley wires are of 00 B. & S. gauge (0·364 inch) and used one for each direction of running. The rails are of girder type weighing 87 lbs. per yard, jointed by Dick, Kerr & Co.'s "Dicker" joint ; the joints are bonded with No. 0000 "Neptune" bonds

and cross-bonded every 120 feet. The gauge is standard, 4 ft. 8½ in. There are nine double-decked motor cars fitted with Brill 21 E. single trucks, with two 25-H.P. motors to each car, and controllers of the solenoid blow-out pattern. There are on order six single-decked cars. The double-decked cars have a capacity of twenty-passengers inside and thirty-four outside, and the single-decked cars will carry thirty-two passengers. There are no grades of importance on the line, and the cars are fitted only with hand-brakes, and, for emergency, arrangements are made for short-circuiting the motors. The lighting station has been run since 1891 by the Corporation, but the tramway has only just been opened. G. H. B.

2335. *Power Transmission at Mescla, France.* (Elect. World and Engineer, 36. pp. 159–161, Aug. 4, 1900.)—This station has been laid down to supply the tramway system which is linking together the towns along the Riviera from Cannes to Mentone. The generating plant consists of three 500 kw. three-phase alternators, each flexibly coupled to a separate turbine. The machines have twenty poles and deliver current at 10,000 volts and twenty-five periods. The turbines are of the centripetal type, with twin conical wheels governed by regulators of the Escher Wyss oil-pressure type. The aerial line consists of six wires, each of 7·5 mm. diam., supported on triple petticoat insulators attached to 35 to 40 feet iron lattice poles, spaced 110 to 130 feet apart. At one place there are two spans of 230 feet each. It may be mentioned that a great deal of the material had to be transported on mule-back over rugged mountain-paths ; in some places even the water for mixing cement in which the poles are fixed had to be so carried.

On the eighteen miles of line between Mescla and Nice, the drop is 10 per cent. There are three substations, the principal at Saint Agathe, transmitting current at 5,000 volts (six 55 kw. transformers) through lead-covered cables to subsidiary substations at Californie for the Cannes tramways, and at Beaulieu for the Monte Carlo tramway. The Saint Agathe substation contains steam plant consisting of two 700-H.P. double cylinder Corliss engines belted to the motor generators. These motor generators consist of a 530 kw. 9,000-volt synchronous motor, direct connected to a 500 kw. 550-volt compound railway generator running at 300 r.p.m. There are also in this substation two rotary converters with six 20 kw. static transformers, and a small 35 kw. motor generator with its three transformers, which delivers current at 75 volts and serves to boost the lines running to Contes.

The low-tension feeders are nearly all underground, of armoured cable, 0·31 to 0·62 square inch cross-section. In order that the municipal regulations regarding electrolysis may be adhered to, a complete system of pilot wires has been connected to all the important parts of the line.

The rolling stock of the system will comprise one hundred motor cars and many trailers, twenty-two express or freight cars, and three electric locomotives. The cars are made so that they can take current from the trolley wires or from the slot conduit which is employed in the central part of Nice. E. K. S.

2336. *Power Station of the Berlin Tramways.* (Engineer, 89. pp. 546–547, May 25, 1900.)—The three engines at the central electric power station are of the marine type, with triple expansion, and were made by Sulzer Brothers. They have one high-pressure, one intermediate, and two low-pressure cylinders, arranged as twin vertical tandems coupled at 180° with two fly-

wheels. The diameters of the cylinders are 34 inch, 49·2 inch, and 61 inch, and the stroke is 51·2. With a steam pressure of 176 lbs. per square inch and a speed of 85 r.p.m., the H.P. is 1,740 with a cut-off at 0·11 of stroke, and 3,860 with cut-off at 0·5. The steam being superheated, jackets are provided only for the intermediate and low-pressure cylinders. Special care has been taken to secure rigidity in the framing and to minimise vibration. Double-beat puppet valves are used, fitted in the cylinder covers and suspended by double sets of plate springs. All the valve-rods are tubular. The Porter governor is completely enclosed so that it may be continuously lubricated; and the adjustment of the central sliding weight is effected by altering the amount of water in a small tank attached to a lever. Steam is supplied by eight water-tube boilers, each having 303 square metres of heating surface. There are two Schmidt superheaters with independent firing. The dynamos are 16-pole direct coupled, and develop 1,000 kw. at a pressure of 250 to 280 volts. About four tons of copper are used in each, liberal air spaces being allowed in order to diminish armature reaction. The dynamos are connected two in series across the mains.

The efficiency (E.H.P. to I.H.P.), as found from various tests, ranged from 82·6 per cent. to 85·6 per cent., the E.H.P. being about 2,500. The steam consumption per H.P. hour was 9·5 lbs., with a superheat of 113° C., and 11·7 lbs. with saturated steam. The coal consumption amounted to 2·1 lbs. per kw. hour in the former case, and 2·3 lbs. in the latter. W. H. E.

2337. *The Boston Elevated Railway.* **C. B. Fairchild.** (Street Rly. Rev. 10. pp. 121–130, March; 185–195, April; and 246–256, May, 1900.)—The track, which is double throughout, is partly elevated (for six miles), partly subway, the two being connected by inclines. It crosses the Charles River on the upper deck of a large drawbridge, which, with the approaches, constitutes an interesting feature of the system. Details are given of the elevated structure and its foundations. Where the shadows of the plate cross-girders would be objectionable, lattice girders are used. The draw-span (illustrated) over the Charles River is 240 ft. long, 100 ft. wide, and 23 ft. above high-water mark. It provides for two 29-ft. roadways and two 10-ft. side paths, in addition to the double car tracks. The revolving mechanism is within the circular base of a central pier, 54 ft. in diameter. The load is supported on solid steel wheels placed close together. Two electric motors are used for rotating the bridge, and two hydraulic lifts at the ends of the structure lock and help to support its ends when closed. A section of the track on the elevated structure is given. The conductor rail is supported at one side of the track on insulating blocks and is made of ordinary 85-lb. track rails connected by continuous joints.

Rolling Stock.—The cars for the elevated railway are 46 ft. by 8 ft. 6 in. overall, and will have side as well as end doors. A train will consist of two to five cars controlled on the "multiple-unit system," so that all the motors can be operated from any one platform. Three trains of four cars each will be experimentally equipped with different electric systems. Three cars of the type described will be equipped with two 150-H.P. motors, both mounted on one truck, the first with General Electric motors and system of multiple control, the second with Westinghouse motors and method of control, the third with the Sprague system, and each will draw a train of loaded goods trucks. Various automatic air brakes and electric car heaters will be tried at the same time.

The Boston Subway, originally built by the city to relieve congested streets,

is 9,500 ft. long. It is approached by open inclines leading down from the streets with gradients at 5 to 8 per cent. Sections of the subway and approaches are shown. An objection from a passenger standpoint is the excessive noise caused by the echo from the walls, due probably to the trolley wheels. The number of passengers through the subway during the last fiscal year was 233,136,939, the earnings being $9,671,441 and the operating expenses $6,827,150.

Power Stations.—Power for the entire system is supplied from seven stations having a total rated capacity of 26,144 kw., which may be safely overloaded to the extent of 25 per cent. The central power station, recently remodelled, contains a vertical cross-compound condensing engine rated at 4,000 H.P., but capable of working up to 7,000 H.P. The cylinders are 42 in. and 90 in. with 60-in. stroke, and the speed is 75 r.p.m., with a 28-ft. flywheel of the spoke type. The top of the frame stands 34 ft. above the floor. The engine is direct-coupled to a 2,700 kw. generator, which was commenced by the Walker Co. of Cleveland but finished by the Westinghouse Co. It was the largest machine that had been designed. The total weight is 300,000 lbs., the armature is 16 ft. 6 in. in diameter, weighs 115,000 lbs., and is mounted on a 37-in. hollow forged nickel-steel shaft made by the Bethlehem Steel Co. The outside diameter of the commutator is 8 ft. 9 in. The field-magnet frame is of cast steel and provided with hand-holes. The poles are of laminated wrought iron, bolted into the frame, the hand-holes giving easy access to the bolts which hold the poles in place. The normal load of the generator is 4,500 amperes at 600 volts, or sufficient to operate 300 loaded street cars. The condensing plant of this engine is of interest, as it dispenses with the usual air-pumps, and forms and maintains its vacuum entirely by the use of the exhaust steam and the condensing water. It consists of two Buckley injector-condensers attached to the main exhaust-pipes. The exhaust steam enters a hollow cone of moving water at the upper part of the condenser, and in condensing imparts to it a velocity which enables it to carry out the air and vapour into the enlarged port of the condenser below. The condensers are connected to the hot well by air-tight water discharge-pipes of sufficient length to allow the water to be delivered by gravity against the pressure of the atmosphere. Circulating water is supplied by an electrically driven centrifugal pump, and after the vacuum is formed the water is raised 25 feet by atmospheric pressure, thus giving the pump little to do. Automatic relief valves are provided to allow the engine to work non-condensing the instant the vacuum is lost from any cause.

The central power station had originally six triple expansion engines belted through countershafting to multipolar 500 kw. generators. In 1896 these were enlarged to 1,600 H.P. and direct-coupled to General Electric generators. Two of these give 1,350 kw. each and four 1,200 kw. each. There are also two 2,000-H.P. engines direct-coupled to 1,500 kw. generators. The engines are of the Reynolds-Corliss type, made by the E. P. Allis Co. The boiler equipment includes 8 double-decked and 24 single-decked Babcock boilers. An elaborate coal-handling equipment is provided, consisting of a bridge-crane having at the canal end a cab and 80-H.P. motor, which operates ropes controlling a shovel of the oyster-shell type. The coal is piled over wooden tunnels, into which the coal cars run and are filled through chutes. The mining train which supplies the central station is run direct in front of the boilers after being weighed, and the coal dumped down without shovelling. The last new station is the Harvard Power Station, completed in 1898. The boiler equipment consists of six 500-H.P. Babcock boilers, with

economisers and smoke-stack for twice this number. The boilers are fitted with "Acme" stokers, these being the only mechanical stokers used by the Boston Elevated Co. The three main engines are of the compound Corliss type by Allis & Co., direct-coupled to 1,200 kw. General Electric generators.

Rolling Stock.—There are 1,381 closed passenger cars and 1,392 open cars, in addition to 11 mail cars, 2 electric locomotives, 4 service cars, and 1 directors' car; 150 closed passenger cars and 50 12-bench double-deck cars are on order. The miscellaneous equipment includes 188 snow-ploughs. Photographs of the cars and ploughs are given.

Testing Motors.—This is done by the Hopkinson method, a flexible coupling being used to save time in aligning the shafts. Temperature rise and efficiency are determined, liquid rheostats being used with a solution of soda. Temperature rise is electrically determined by the rise in resistance, 1 per cent. increase in resistance being taken as equivalent to 2·5° C. rise in temperature. In order to accurately test the consumption of power while the car is in active service, 60 cars are fitted with wattmeters. The rail-joints are periodically tested by comparing a 3-ft. length of rail, including the joint, with an unbroken length of rail [see Abstract No. 770 (1900)]. The standard size for the trolley wire is No. 0. Owing to the physical conditions, a direct-current system with a number of power-houses properly distributed was preferable to a high-pressure system with a single power-house and transformer-stations. In computing the copper required to give the most economical results for the feeders, the engineer followed a method devised by himself, which was published in the Review for July, 1897. The insulation of the overhead feeders is chiefly of tarred jute, and of those underground, rubber or paper according to the soil. The insulation resistance of the underground cables varies from 200 to 1,500 megohms per mile. The drop in potential varies on the lines from 10 to 15 per cent., except on one or two of the longer lines, where it reaches 20 per cent. In ordering cables or wires, the specification as to purity states that the resistance shall not exceed 0·1157 ohm per mile of 500,000 circ. mils. section. The underground conduits have been constructed both of terra-cotta ducts laid in cement and of cement-lined iron tubes. In moist ground the manholes are built with double walls, with waterproof paper between.

The Street Railway Co. is required by City ordinance to remove all the snow from the streets in the business districts where cars run; this work is difficult and has to be elaborately systematised. E. H. C.-H.

2338. *Deering Harvester Company's Power Station.* (Amer. Electn. 12. pp. 371–379, August, 1900.)—The Deering Harvester Co.'s factory in Chicago consists of buildings occupying 85 acres and containing machinery absorbing 7,500 H.P. In 1898 a 1,000-H.P. three-phase alternating set was laid down, which is now replaced by a large central station designed for 10,000 H.P. The system used is three-phase alternating current at 600 volts. The boiler-room is designed for 13 water-tube boilers, each of 700 H.P., having 10 sq. ft. of heating surface per H.P. The feed-water is heated by a 4,000 H.P. Cochrane feed-water heater and purifier, and also passes through Hoppes feed-water purifiers. It is heated to a temperature of 360° F.

The engine-room contains three Allis-Corliss vertical two-bearing cross-compound engines of 1,100 kw., running at 90½ r.p.m. The cylinders are 28 and 60 in., with stroke of 48 in. The engines exhaust into a central condensing plant of 5,400 H.P., giving a vacuum of 26 in.; the condenser is a Weiss counter-current jet condenser. Each engine drives directly a General Electric

revolving-field three-phase generator between the two cranks of the engine, giving 1,060 amperes per phase at 600 volts. It is cable-wound, with a continuous winding in six slots per pole. The frequency is 40 periods. The exciters are run by independent engines. On the switchboard eleven feeder panels supply different sections of the factory. Circuit-breakers are used instead of fuses. General Electric type induction-motors are used throughout the factory, belted to line shafting; the larger motors are started with a water-resistance, but their rotors are in permanent short-circuit. A starting test on a 75-H.P. motor running light on the shafting showed a momentary rush of current of nine times the full-load current when thrown on the mains without, and but four times with the water-resistance. G. H. B.

2339. *Power Plant of the Western Electric Company's Factory.* (Amer. Electn. 12. pp. 333–338, July, 1900.)—The Western Electric Co. has put down a power plant of an aggregate capacity of 1,550 kw. for supplying power and light to its New York factory.

The system is continuous current at 120 volts. There are two boiler-rooms; the old one contains Babcock and Wilcox boilers for 1,200 H.P., the new one for 1,250 H.P. Steam is supplied at 140 lbs. per square inch. The feed-water is heated by Green economisers. The new boilers are fitted with induced-draught blowers. Coal is delivered from waggons through a chute below the street to an endless conveyer taking it to storage and service bins; from these it is shot into weighing hoppers moving on an overhead track in the boiler-room. Ashes also are removed by the conveyer. The engine-room contains four Ball & Wood Corliss-type vertical cross-compound engines running at 150 r.p.m., each of 350 kw.; also two similar engines of 100 kw. and 50 kw. taking steam at 100 lbs. per square inch through a Foster reducing valve. Independent steam-driven Conover jet-condensers and air-pumps are used.

Each large engine drives directly a Western Electric multipolar dynamo, giving 2,900 amperes at 120 volts, capable of an overload up to 4,000 amperes.

The interior wiring in the building is in iron-armoured conduits. The output during the day varies from 7,500 to 8,000 amperes, the greater part of which is motor-load. The motors are in all cases belted to shafting. The efficiency of the plant is 260–270 watt-hours delivered per pound of pea-coal.

G. H. B.

2340. *Power Station of the North-Western Elevated Railroad, Chicago.* (Street Rly. Rev. 10. pp. 369–375, July, 1900.)—The ultimate capacity of the station will be 14,000 H.P., and of this 7,200 H.P. is now installed. The completed building will be 430 ft. long by 110 ft. wide, with the chimney-stack in the centre. This stack is 217 ft. high and 16 ft. internal diameter, the inner fire-brick shaft being 110 ft. high.

The boiler-room contains twelve Babcock & Wilcox water-tube boilers set in batteries of two, fitted with extended front Murphy automatic smokeless furnaces. The live steam-pipes are extra heavy lap-welded of wrought iron, the exhaust-piping being of cast iron. The steam valves are of the bronze-seated gate type of the Chapman make. The exhaust is ordinarily led to a Weiss central condenser, in which the air-pump is an air compressor of an improved type, working free from water, and the circulating pump of the Bibus rotary type, handling only the cold injection water. When the condenser is not working, steam is taken above the roof through a 40-inch diameter free exhaust-pipe. The feed-water is heated by two Berryman feed-

water heaters, with a capacity of 2,000 H.P. each; the water is forced through these by means of three Duplex pumps of the vertical type by Worthington. All the feed-pipes are in duplicate.

The engine-room contains three engines made by E. P. Allis & Co., of the cross-compound condensing type, fitted with Corliss gear, and driving direct Siemens & Halske 1,500 kw. generators. The diameter of the cylinders are 30 in. and 60 in. respectively, with a stroke of 5 ft.; the speed is 75 r.p.m. In addition to the large sets there is also another one of 750 kw. capacity, similar to the above, the cylinders being 23 in. and 46 in. diameter and the stroke 4 ft.

The shafts are made by the Bethlehem Steel Co., and are of fluid compressed open-hearth steel, hollow forged over a mandril. For the large engines the shafts are 28 in. and 22 in. diameter at the flywheel and the bearings respectively, the bore being 8 in. diameter. The flywheel of the large engines is 25 ft. diameter, the small engine 20 ft., and each engine has two governors, one regulating the cut-off in both cylinders, and the other to trip a safety cut-off when the safe speed is exceeded.

The switchboard is two-decked, the station panels being below and the feeder panels placed above. Coal storage is provided up to 1,500 tons, the bunkers in the boiler-room holding another 300 tons. The capacity of the conveying system is 50 tons per hour, the ashes being also removed by means of a conveyor.

The article is well illustrated by sixteen figures, and very full details are given of the piping, receivers, and Weiss condensers, and other mechanical details. E. K. S.

2341. *Electrical Equipment of the Indian Head Smokeless Powder Factory.* (Elect. World and Engineer, 36. pp. 275–278, Aug. 25, 1900.)—System: Double-current generators, supplying direct current for traction and two-phase alternating current for lighting and motive power. The engine-room contains two compound enclosed Westinghouse engines of 500 H.P. each, with cylinders 20 and 34 inches diameter, 16 inches stroke, and one of similar type of 150 H.P., with cylinders 12 and 20 inches diameter and 12 inches stroke. Each engine drives directly a Westinghouse generator. The two large machines are each of 250 kw. output, delivering direct current at 550 volts from the commutator, and two-phase alternating current at 400 volts and 60 periods. The small machine is rated at 75 kw., delivering two-phase current only, at the same pressure and frequency as the others. The exciters are driven by belts from the shafts of the generators. A transformer of 18¾ kw. capacity is used to raise the pressure to 1,100 volts for a long lighting feeder. The double-current generators are run in parallel on either system, and with the alternator if desired; they are provided with series field coils, which do not interfere with paralleling. Induction motors are used for driving the machines in the factory, the absence of commutators being a feature of the first importance in the manufacture of explosives. The tramway is equipped on the overhead trolley system, except for a distance of about half a mile, where it crosses the gun ranges; to prevent damage from projectiles this part of the track is equipped with the Westinghouse electromagnetic surface contact system, which is described in detail. The rails are of the flanged type, weighing 56 lbs. per yard. There are two 100-H.P. freight locomotives and a 70-H.P. combined passenger and freight car. The locomotives haul a load of 30 to 40 tons, and pass from the trolley to the surface-contact system without stopping. The system has operated with complete success. A. H. A.

2342. *Power Transmission at Lindsay, Canada.* (Canad. Elect. News, 10. pp. 89–93, June, 1900.)—A fully-illustrated description of this electric power transmission scheme, whereby power is derived from the Fenelon Falls on the Scugog River. Current is generated by a 400 kw., 500 volt, three-phase generator, direct coupled to a pair of 40-inch Samson turbines. The generator pressure is transformed to 11,600 volts for the overhead transmission line to Lindsay, distant about fourteen miles, where the energy is utilised for the usual lighting and power purposes of the town. E. D. P.

ELECTRIC TRACTION AND AUTOMOBILISM.

2343. *Electrolysis from Earth Returns.* **G. Claude.** (Soc. Int. Élect., Bull. 17. pp. 238–250, June, 1900. Additional Notes, pp. 251–260.)—After briefly reviewing previous researches on the electrolytic phenomena met with in electric traction due to the return currents, the author outlines the accepted theory as to the path of the currents, which has given rise to the regulation that the fall of potential in the rail return shall not exceed 5 volts—a safe and effective rule. Certain experiments made by the author, however, show that the relation between the earth current and the difference of potential to which it is due, agrees almost exactly with Ohm's law, which would not be the case if the conduction were electrolytic. Upon applying a difference of potential between the rails and neighbouring water-pipes equal to that met with in ordinary working, large currents were found to flow through the earth; but when the actual currents flowing in the pipes were measured directly, their values were ascertained to be only $\frac{1}{10}$th or $\frac{1}{50}$th of those above mentioned. Thus it was shown that by far the greater part of the stray current flowed through the earth, not through the pipes; moreover, the author estimates that the stray currents amount to from 12 to 30 per cent. of the total current returning to the station, while in most cases the current flowing in a pipe does not exceed a small fraction of an ampere. These results are contrary to what was formerly supposed to be the case. By passing a known quantity of electricity between leaden plates buried in the ground the author ascertained that the actual corrosion was far below the theoretical value, and when the difference of potential was only about 1 volt, the loss of weight was only $\frac{1}{25}$th of the calculated value. Tests made by Herrick with iron plates (Street Railway Journal, May, 1900) give exactly similar results. By using several return feeders, or even by spreading out branches of equal resistance from the end of a single feeder to several widely separated points on the rails, bunching of the stray currents to one point can with great advantage be prevented. The same end can be attained by connecting the negative pole of the generators to the trolley wire and the positive pole to earth. The stray currents flowing from pipes to rails will then be distributed over a large area, and consequently weakened in intensity at any one point. The author concludes by approving of the Board of Trade rule that the potential difference between rails and pipes shall not exceed 1·5 volts, and considers that to connect the pipes to the rails near the return feeding-point is a harmful practice.

In the notes appended to the paper the author gives details of the tests carried out by him, showing the close proportionality between the stray currents and the potential differences to which they are due, the unexpected magnitude of the currents, and the superior conductivity of gas-pipes compared with water-pipes. The method of measuring the currents flowing in a pipe

consists in applying a voltmeter between two points in the pipe about 100 yards apart, and obtaining the reading e_1, then immediately repeating the reading when the same points are shunted by a low resistance, giving e_2. The current i flowing in the shunt is measured with an ammeter. The ratio $e_1/(e_1 - e_2)$ is a constant, which, multiplied by the maximum current observed, i, gives the maximum current flowing in the pipe. The accuracy of the method is discussed, and examples of its application are given. The mode of measuring the total return current is also explained. The author recommends the Falk (cast-weld) bond in place of copper bonds. By connecting the pipes to the rails the stray currents in the former are multiplied, it may be, a hundredfold, with consequent danger of corrosion at bad joints in pipes, although the current does not leave and re-enter the pipe at a joint, but over a considerable length on either side of it. This being so, it is better not to connect the rails with the pipes. A. H. A.

2344. *Rail Bonds.* (Tram. Rly. World, 9. pp. 369–372, Aug., 1900.)—A description of the various bonds which are now in use, viz. : The Chicago, Chicago Crown, Falk cast-iron weld, Lorrain Steel Company's electric weld, and the various bonds in which the Edison-Brown plastic alloy is used, *i.e.*, the original cork type, the plastic plug, and the copper plastic bond of H. P. Brown.

A bond to be of permanent use must be absolutely reliable as regards conductivity, and the Falk cast bond sometimes fall short of this owing to blow-holes. It is, however, much used. In making the cast-iron bond it is important that before fixing the moulds, the sides and bottom of the rails should be cleaned with an emery-wheel or sand-blast. The cast-iron, which is run in at much greater heat than in ordinary casting, cools rapidly on the outside surface, thus causing a tremendous pressure to be exerted on the molten metal still in contact with the web and foot of the rails. As the metal is poured from one side and comes in contact with the web or thinnest part of the rail at its greatest heat, this part of the rail is brought to a white heat, and owing to the tremendous pressure the cast iron is practically forced into the interstices of the steel, as is shown by the fact that if torn away from the web of the rail it usually brings away part of the rail with it.

In fixing the plastic bond, the contact spots are cleared of rust and scale by a heavy, broad-pointed track-drill, or a specially designed emery-wheel, moistened with soda and water (oil must never be used). The following tests show the low resistance obtained :—

	Amps.			
	100	500	1,000	1,50
Ordinary single plastic bond on 60-lb. rail, volts drop	·004	·02	·04	·06
Ordinary single plastic bond on 90-lb. rail, volts drop	·004	·0095	·017	·04
Plastic plug bond on 60-lb. rail, one pair of ¾-inch holes, volts drop	·005	·025	·05	·086

Plastic bonds put down in Dublin five years ago, which have been recently taken out, show as good a contact as on the day they were put in

The material has remained perfectly soft, and the contacts are still quite bright. Experience on the Boston Elevated Railroad after two years, and the Metropolitan West Side Elevated Railway of Chicago after three years' use, bear out the same result. The plastic bond gives almost equal conductivity to that of the rail, the cost being but slightly higher than the usual copper bonding, which only secures a joint having a conductivity of $\frac{1}{2}$ to $\frac{1}{6}$ that of the rail. E. K. S.

ELECTRIC LAMPS AND LIGHTING.

2345. *Arc-Lighting from a 250-Volt Supply.* **W. B. Sayers.** (Inst. Elect. Engin., Journ. 29. pp. 382–393, April, 1900.)—The introduction of 250–500 volts supply pressure in Glasgow has led the author to go into the question of economical arc-lighting for such circuits.

Enclosed arc-lamps are obtainable which burn singly across 250-volt circuits, but the energy consumed per c.p. hour is very great, and the colour of the light is unsatisfactory with these lamps. The usual methods of many lights in series, and the dissipation of energy in resistances are discussed. The relative merits of enclosed—and open—arc lamps are next considered, and the following table of comparison, representing the results of tests made by the author, is given :—

	Open-type Arc.	Enclosed-type Arcs.		Incandescents (new lamps), Clear Globes.			
	5 in Series. S.R. = 4 ohms. C=10Amps Watts=500	2 in Series. S.R. = 12 ohms. C=4 Amps. Watts=500	Single. C = 2·75 Amps. Watts=680	16, 16-c.p. C = 4·4 Amps.		31, 8-c.p. C=4·5 Amps.	
				Watts =1,100	Watts = 500.	Watts =1,120.	Watts = 500
Relative Luminosity	1	0·475	0·1	0·68	0·31	0·75	0·333
Do., do.	3·25	1·54	0·325	—	1	—	1·07

Note.—Voltages across lamps and resistances = 250.

The 250-volt enclosed lamp does not meet the difficulty, inasmuch as it gives about one-third the light of a group of incandescents and one-tenth the light of an open arc lamp, all consuming energy at the same rate.

Where a sufficient number of lamps is required, there are two methods of overcoming the difficulties : (1) The use of a transformer to reduce the supply pressure to a suitable voltage for running single lamps in parallel ; and (2) the use of a special "ganger" switchboard devised by the author. The latter method consists in running a separate pair of leads from each lamp to a pair of plug connections ; plug and socket connections are provided whereby the number of lamps required are put into circuit in series with each other, in groups of four or five, and any set of lamps which is incomplete is run with a series resistance to correspond to the full complement of lamps. The disadvantages of this system are that means of communication with the switchboard by bells, telephones, or speaking-tubes would be required, and that all lamps would have to be of the same size so as to be interchangeable. A

method somewhat similar to this has been in use at St. Pancras Station by the Midland Railway Company for some years.

The best method, where a number of lamps is required, is the use of a step-down transformer with the lamps simply in parallel on the secondary circuit. The advantages of this system are: Each lamp would be under independent control, and consequently burning economically; the size of any lamp may be fixed according to requirements; the exact number of lamps required may be fixed; and the voltage at each lamp terminals may be adjusted for the best results. The first cost of, and the electric loss in, the transformer are the chief drawbacks, but are more than outweighed by the general advantages and economy of the method. It is suggested that the Supply Company should bear the loss in the transformer by fixing the meter on the low-pressure side, the consumer to pay the first cost of the transformer. With regard to the best pressure to be used on the secondary side of the transformer, the author submitted three questions relating to this matter to several well-known arc-lamp manufacturers. The answers to these questions are given in full.

The paper concludes with two sets of curves. The first one shows the cost of running sets of five lamps in series on circuits. The second set shows the results of using the transformer system. E. D. P.

2346. *Comparison of Open and Enclosed Arc Lamps for Street Lighting.* **H. H. Wait.** (Amer. Electn. 12. pp. 274–276, June, 1900.)—The author states that the enclosed lamp has practically driven the open arc from the field for constant-potential circuits; and that, for alternating circuits of either class, open arcs are no longer considered. The author briefly discusses in a general manner the results which have been obtained from time to time in tests of open and enclosed lamps by various people; the distribution of light, the deposit inside globes and its effects, the absorption of globes, the colour of the light, the watts per mean hemispherical candle-power, and so forth, basing his remarks on the requirements of street lighting. Polar curves are given of the mean results of various tests on open and enclosed arcs, and also a curve showing the variation, according to distance from the lamp, of the intensity of illumination at the street surface.

The following table of figures dealing with the relative operating expenses of lamps is given :—

Operating Expenses per Lamp per Year of 3,800 hours.

	Open direct-current trimmed daily.		Open direct-current double carbon, alternate days.		Enclosed direct current.		Enclosed alternating current.	
Trimming	$7·30	$11·00	$4·50	$6·50	$2·50	$3·15	$4·70	$5·80
Carbons	7·30	7·50	6·50	6·80	1·50	1·70	2·00	2·30
Outer globes	·40	·70	·30	·50	·25	·25	·30	·40
Inner globes	......	......	......	......	1·00	1·05	1·30	1·40
	$15·00	$19·20	$11·30	$13·80	$5·25	$6·15	$8·30	$9·90

It is then shown that the saving of nearly $10 per lamp by using enclosed instead of open arc lamps for all-night running would be a complete gain if the installation be a new one; or the change may be more or less profitable if radical changes are being made at the generating station. The author estimates the cost of changing from several small 10-ampere machines operating open arcs to large 6·8-ampere units operating enclosed arcs at $30 per lamp;

in which case, the change being so expensive, the author concludes that the bulk of the saving must take place in the increased efficiency of the generating plant. The saving in operating expenses brought about by the change in generating plant may frequently be very high and the advisability of the change must be figured out accordingly [see also Abstract No. 1201 (1900)].

E. D. P.

2347. *Photometric Value of Arc Lamps.* (Elect. World and Engineer, 35. pp. 824–826, June 2, 1900.)—This is a report presented to the National Electric Light Association (U.S.A.) by **C. P. Mathews,** who performed the photometric work and evolved the methods and devices used. Briefly, the improved methods introduced are as follows: The use of two mirrors instead of one for directing the light from its source to the photometer. These mirrors are placed on opposite sides of the arc and render the illumination of the photometer disc more uniform. The use of a rotating disc with sectors, which reduces the effect of colour difference. The recording drum used to correct retinal fatigue was improved by the addition of an electromagnetic recorder. Particulars of these devices and of the arrangement of the apparatus are given.

With an opalescent inner globe the globe itself becomes luminous by diffusion, and this effect changes with the position of the arc within the globe. Tests were made, using the same inner globe and the same pair of carbons, but with the arc at certain definite heights inside the globe—in each case the arc being placed at the centre of the mirror system. The largest amount of light was obtained with the arc at the mid-point. The causes of this are pointed out, the question resolving itself into a subject for investigations as to the carbons used, shape of globes, &c. Curves are given showing the results obtained with three different lengths of the lower carbon. The report includes the discussion of tests obtained with eight different makes of 110-volt, direct-current, enclosed lamps. They were tested just as sent from the makers, under uniform conditions as follows: The same brand of carbons throughout; an opalescent or milky inner, and clear outer globe, as supplied; an opalescent inner and opalescent or milky outer globe, as supplied. Curves are given and discussed. Some of the results are as follows:—

At a common terminal E.M.F. of 110 volts, seven of these lamps take an average current of 4·90 amperes, which means an average total power consumption in each lamp of 539 watts. With 80 volts at the arc, this power is divided into 147 watts wasted in the resistance coils and 392 watts in the arc. The average yield of light, expressed as mean sperical intensity is—

Opalescent inner, no outer	=256 H.U.
Opalescent inner, clear outer	=207 H.U.
Opalescent inner, opalescent outer	=177 H.U.

Hence the power required to produce one unit of light in this type of lamp is—

Opalescent inner, no outer	=2·10 watts.
Opalescent inner, clear outer	=2·66 watts.
Opalescent inner, opalescent outer	=3·04 watts.

Similar tests were made with seven different makes of 110-volt, alternate-current, enclosed lamps. Curves are given and a summary of the results.

The mean power consumption of the seven lamps was 417 watts. The average value of the mean spherical intensity is—

With clear outer globe .... 159 H.U.
With opalescent outer globe .... 130 H.U.

Therefore, as light producers, the average efficiency is—

With clear outer globe .... 2·62
With opalescent outer globe .... 3·20

reckoning in watts per mean spherical Hefner unit. The mean power in the arc is 342 watts, and in the mechanism 74 watts.

Comparisons are drawn, based on the results obtained, between the direct-current and the alternate-current lamps as sources of light. The effect of the coating of ash on the inner globe is discussed, and the following table of the averages of the whole set of experiments is given, the first part relating to direct-current and the second part to alternate-current lamps.

No.	Current.	Watts Consumed In Lamp.	Power Factor Lamp.	Watts Consumed In Arc.	Power Factor Arc.	Watts Consumed Mechanism.	Mean Intensity in H.U. Spherical. Op. Outer.	Mean Intensity in H.U. Spherical. Clear Outer.	Mean Intensity in H.U. Lower Hemi-spherical. Clear Outer.	Mean Watts Per Spherical H.U. Op. Outer.	Mean Watts Per Spherical H.U. Clear Outer.	Mean Watts Per Lower Hemispherical H.U. Clear Outer.
1	5·01	551		401		150	172	235 256[1]	332 362[1]	3·10	2·37 2·18[1]	1·66 1·52[1]
3	5·08	559		406		152	195	216	282	2·85	2·60	1·99
4	4·76	524		381		143	127	189	208	4·12	3·76	2·52
5	4·16	458		333		125	154	174	221	2·96	2·63	2·07
7	4·76	524		381		143	203	233	317	2·63	2·20	1·65
9	4·84	532		387		145	182	226	281	2·83	2·38	1·89
10	4·99	549		399		150	202	242	309	2·74	2·24	1·77
12	4·87	536		390		146	178	195	230	3·05	2·66	2·33
	4·9	529		384		144	176	207	272	3·03	2·60	1·98
101	6·40	448	·63	340	·82	108	127	141	206	352	317	2·17
102	6·79	459	·61	375	·73	84	146	203 176[2]	236 266[2]	3·31	226 260[2]	1·94 1·72[2]
103	5·89	424	·65	344	·75	80	116	130	147	3·66	3·15	2·88
105	6·20	414	·61	382	·80	32	128	187	219	3·24	2·20	1·89
106	6·12	378	·56	298	·70	80	132	158 152[2]	169 254[2]	2·82	2·56 2·49[2]	2·23 1·48[2]
108	6·48	457	·64	383	·80	74·5	133	175	211	3·30	2·61	2·16
110	6·18	339	·49	276	·72	63	140[1]	126	143	2·41[1]	2·68	2·37
	6·29	417	·60	342	·76	74·5	130	159	190	3·31	2·66	2·23

[1] Condition of no outer globe. [2] Condition with shade on lamp.

E. D. P.

2348. *Hackl Alternate Current Arc Lamp.* **de Lénart.** (Soc. Int. Élect., Bull. 17. pp. 235–237, June, 1900.)—In this lamp, which is made by Ganz & Co., nearly the whole of the light emitted is utilised in lighting the lower hemispherical zone. The essential feature of the lamp consists in that the carbons are inclined to the axis of symmetry of the lamp at an angle of 45°, and are, therefore, at an angle of 90° to each other. Each carbon is supported by a rack connected to a train of gearing controlled by a lever. The two-toothed wheels, belonging to the two carbons, are connected by a common wheel, the arbor of which bears an aluminium disc. The regulating system comprises a series electromagnet. In its movement in one direction or the other, the brake-lever locks the disc, or allows it to rotate. The carbons are cored and flattened at their upper side so as to prevent change in the position of the arc. These lamps work at 30 volts and 10–16 amperes. A 12-ampere lamp consumes 360 watts; the regulating rheostat in series, 60 watts on a 105-volt circuit; a distributing apparatus for enabling three lamps to work in parallel consumes 30 watts; the light of each lamp is equal to 500 candles, so that one candle corresponds to 0·86 watt, which is the commercial efficiency. Since only 347 volts are consumed by the arc itself, the efficiency thereof is 0·69 watt per c.p. C. K. F.

2349. *Street Lighting with Arc Lamps.* **A. L. Rice.** (Amer. Electn. 12. pp. 379–380, Aug., 1900.)—The author discusses various systems of lighting with alternating arc lamps, with or without transformers and inductance coils. A table is given showing the comparative results with transformers and inductance coils respectively; in the former case an enclosed lamp taking 450 watts in the arc, 613 altogether, costs £32·3 to instal and £12 per annum to run, with a power factor of 0·78; and in the latter case, the same lamp takes 598 watts in all, costs £32 to instal and £11·2 per annum to run, the power factor being 0·89. A. H. A.

2350. *Arc Lamps and Cost of Lighting.* **W. M. Stine.** (Amer. Electn. 12. pp. 327–330, July, 1900.)—In this paper the author gives the characteristic features, illustrated by curves, of direct and alternating current open and enclosed arcs, the efficiency of globes of different kinds of glass, and the following table, showing the relative costs of installation and operation of various types of arc lamps, viz.:—

Watts.	Enclosed Arcs.	Cost per Lamp.	Cost per Year.
400	Alternating current	$146·50	$52·86
450	" "	155·24	57·85
300	Direct current	117·90	41·75
450	" "	147·00	56·07
	Open Arc.		
450	Direct current	142·00	62·58

C. K. F.

2351. *High-Voltage Lamps.* **A. Werner** and **J. Hardwick.** (Elect. World and Engineer, 35. p. 778, May 26, 1900.)—The authors have attempted to make lamps for 500 volts by combining infusible metals, such as iridium, osmium, ruthenium, and rhodium, with rare earths. The filaments were made by dipping threads into a mixed solution of one of the metallic salts and the nitrate of a rare earth. The carbon was burnt out by passing a heavy current. W. R. C.

REFERENCES.

2352. *Electric Railways.* (Zeitschr. Elektrotechn., Wien, 18. pp. 243–247, May 13, and 257–259, May 20, 1900; from the Zeitung des Vereines Deutscher Eisenbahn-Verwaltungen, No. 22, 1900.)—A general paper on the problems presented by electric traction on railways. The paper is accompanied by three tables giving statistics of persons carried, receipts, &c., on eleven lines worked by electricity in Hungary, nineteen lines in Austria, and one in Bosnia, some of the lines, such as the Budapesth Underground, Czernowitz, Pilsener, Saragevo, &c., carrying regular railway traffic. E. K. S.

2353. *Electric Distribution in Paris.* **J. Laffargue.** (Ind. Élect. 9. pp. 178-196, May 10, 1900.)—Particulars and statistics of the various companies.

2354. *Central Station Work.* (Amer. Electn. 12. pp. 259–274 and 277–278, June and July, 1900.)—A series of articles dealing with questions arising out of central station work. The various authors and the titles of their papers are as follows:—

R. C. Carpenter (pp. 259–260), The Selection of an Engine for a Power Station. **R. A. Douglass** (pp. 261–263), Boilers for Electric Power Plants. **J. F. Hobart** (pp. 263–266), Stoking in Central Stations. This article deals mainly with mechanical stokers, including the Wilkinson, Murphy, Roney, and Playford types. **J. Francis** (pp. 266–269), Handling Coal in Central Stations. **P. C. Percy** (pp. 269–270), Steam Plant Auxiliaries. A short article on the most economical method of driving feed pumps. **W. D. Ennis** (pp. 270–274, and 324–327). Arrangement of Central Station Piping. **L. B. Mather** (pp. 277–278), Electrical Equipment for Small Central Stations.

2355. *Electrical Equipment of Office Buildings.* **R. P. Bolton.** (Eng. Mag. 19. pp. 381–390, June, 1900.)

2356. *Tests of Controlling Systems for Electric Railways.* (Street Rly. Journ. 16. pp. 364–368, May, 1900.)—This paper describes tests made by the Boston Elevated Railroad Co. on the Sprague, General Electric, and Westinghouse controlling systems. Descriptions are given of the several systems, that of the General Electric Company being illustrated by diagrams and some detail drawings. This last-mentioned system is based on E. Thomson's U.S. patent No. 617,546. C. K. F.

2357. *Electricity Works in Germany.* (Elektrotechn. Zeitschr. 21. pp. 552–570, July 5, 1900.)—A list in tabular form of the various electric light stations in Germany, 652 in all, giving particulars about each.

2358. *Controller Diagrams.* (Street Rly. Journ. 16. pp. 459–460, June, 1900.)—Several of the diagrams, at present in use by the General Electric Company of America, are given, showing the complete wiring of the car.

2359. *Statistics of Electric Power Production.* **P. Dawson.** (Engineering, 69. pp. 434–435, April 6; 539–540, April 27; and 635–636, May 18, 1900.)

2360. *Preventing Fluctuations of Light.* **K. Schindler.** (Elekt. Runds. 17. pp. 182–183, June 15, 1900.)—In this paper, the various methods of preventing fluctuations of light on electric lighting systems are discussed, and an example given of calculating the dimensions of a fly-wheel for a dynamo. C. K. F.

2361. *Madras Electric Tramways.* (Tram. Rly. World, 9. pp. 132–134, April, 1900.)—This article fully describes and illustrates the overhead-trolley and tramway system of Madras. E. D. P.

2362. *Electric Traction.* **A. H. Binyon.** (Mech. Eng. 6. pp. 230–232, Aug. 18, and 275–276, Aug. 25, 1900. Abstract of a paper read before the Society of Engineers, June 11, 1900.)—A general discussion of the equipment of power stations and traction systems using the trolley. W. R. C.

2363. *Cost of Electric Power.* **P. Dawson.** (Engineering, 69. pp. 701–704, June 1; 739–740, June 8; and 841–845, June 29, 1900.)—An important article in which the author discusses the relation that may exist between the first cost of a plant and that at which power can be produced. The initial cost is taken to be made up of: (i.) Land and buildings; (ii.) Plant including all machinery in the station; (iii.) Mains, feeders, and distributors; (iv.) Miscellaneous apparatus, &c., including meters, instruments, cost of provisional orders, and such like.

In all thirty-four tables are given, illustrating various costs from actual results obtained in lighting and traction work in Europe and America. E. C. S.

2364. *Cost of Electric Power Plants.* **P. Dawson.** (Engineering, 70. pp. 112–113, July 27, 1900.)—The author seeks to show that the larger the plant, the nearer the costs as obtained from actual working results in various countries agree. Usually the costs are lower in a large than in a small plant. The cost of installation of the actual plant itself is examined in more detail than was the case in the author's previous articles (see preceding Abstract). E. C. S.

2365. *Indispensable Accessories of Electric Traction.* **H. E. P. Cottrell.** (Elect. Rev. 46. pp. 907–908, June 1; 965–967, June 8; 47. pp. 240–242, Aug. 10; 297–299, Aug. 24; and 492–494, Sept. 28, 1900.)—These articles illustrate and describe the American standard switchboard panels and connections, and also give data from various American switch catalogues. The average cost in pence of a single, double, and triple-pole single-throw switch can be found by multiplying the rating by 2, 3, and 4 respectively. For double-throw, the multipliers become 5, 9, and 13 (pp. 907–967). This is followed by a descriptive reproduction of the catalogue of Ward-Leonard enamal rheostats and a list of the apparatus on recent switchboards, put up by R. W. Blackwell & Co. (pp. 240–242). In the fourth article the switchboard list is concluded, and trolley wire and overhead line material is described (pp. 297–299). [See also Abstract No. 1985 (1899).] E. H. C.-H.

2366. *Burgdorf-Thun Polyphase Electric Railway.* **W. Rung.** (Elect. Rev. 47. pp. 576–578, Oct. 12; 615–616, Oct. 19; 695–697, Nov. 2; and 752–753, Nov. 9, 1900.)—Translated from Ingeniören.

2367. *Electric Railways in Italy.* **E. Bignami.** (Eng. Mag. 20. pp. 173–189, Nov., 1900.)—An article in popular form, giving general information about various Italian tramways.

2368. *Electricity in Mining.* **G. F. Walker.** (Feilden, 3. pp. 560–572, Nov., 1900.)—An article dealing with various electrical appliances, such as pumps, coal cutters, rock drills, locomotives, &c.

2369. *Electric-Lamps.* **A. Blondel.** (Écl. Électr. 24. pp. 464–471, Sept. 22, 1900. Paper read before the International Electrical Congress at Paris.)—A description of the progress in arc and glow-lamps, and of lamps with filaments other than carbon. A translation of the paper in abstract appears in Electrician, 46. pp. 54–56, Nov. 2nd, 1900. E. C. R.

TELEGRAPHY AND TELEPHONY.

2370. *Postel-Vinay Multiple Telephone Switchboard.* **J. Anizan.** (Journ. Télégraph. 24. pp. 169–173, Aug., 1900.)—This switchboard is shown at the Paris Exhibition, and provides for 15,000 lines. The panels are vertical, and the annunciators and ring-off drops, as usual, are above the jacks. In French boards the jacks are generally of "double rupture," so that the annunciators are completely isolated from the subscribers' circuits during conversation. However, the Administration permits of the employment of jacks in derivation, provided means are adopted for cutting out both annunciators when subscribers are in communication. In this system the annunciators are devised to meet this requirement. They are composed of two electromagnets placed one above another. The upper one serves for the call. That below is for the automatic restoration of the shutter. When the armature of this latter is attracted it opens two contacts, which are the terminals of the upper coil, and thus cuts it out of circuit. The current actuating the lower magnet comes into circuit when the plug is thrust home to the ring of a jack, the third conductor of the plug cord being joined to one pole of a battery, whose other pole is joined to the lower electromagnet, the other end of this magnet being connected to the ring of the jack. The isolation of the annunciator upon putting a plug into the jack constitutes an original feature in this switchboard. The same operation is performed upon the circuit of each subscriber. The ring-off annunciator alone forms a derived circuit when the listening-key is restored and subscribers are in communication. This has a higher resistance and greater self-induction than the calling-annunciator, and consequently hearing is good. Being the only annunciator in circuit the ring-off is certain. In these annunciators the armature of the upper coil maintains a curved lever in an upright position; this lever, which is hinged at its centre, has the subscriber's number plate at right angles to its lower end. When the armature is attracted the lever falls inwards, and the number plate is exposed. When the restoring coil below acts, its armature kicks the lever back to its position of rest. The "test" circuit is arranged as usual in connection with all the rings of the jacks. To ascertain whether a line is free or otherwise the operator touches the ring with the point of a plug, when a "click" is heard in the telephone if the line is being used, due to the current coming in from the "test" circuit through a third winding on the induction coil and the telephone. Lamps can also be used as signals instead of ordinary annunciators, and as shown on one section of this board, for the subscribers' lines they are placed under the corresponding local jacks, and, for the ring-off, opposite to each pair of cords. This arrangement saves fatigue to the operators. E. O. W.

2371. *Mors-Mandroux Telephone System.* **L. Montillot.** (Électricien, 20. pp. 150–153, Sept. 8, 1900.)—An arrangement for a number of telephones on one common metallic circuit without a central exchange, shown at the Paris Exhibition. The offices are in parallel, and the speaking apparatus is, as usual, brought into circuit by removing the telephone receiver from the hook-switch. The peculiarity is the apparatus for the selective call, and the indication that the circuit is "engaged." In each office is a keyboard with

keys numbered to correspond with the stations on the circuit, and one key for "rest"; a clockwork movement causing two axes to turn, which operate to regulate the number and succession of currents of "call," and an electro-magnet whose polarised armature carries an escapement controlling a needle which moves over a dial numbered similarly to the stations. When the clockwork is going it turns a horizontal rod running the length of the key-board as well as a distributing wheel divided into sectors, so that when springs or brushes are suitably arranged to come into contact with these sectors severally, positive and negative currents from the battery can be sent into the circuit in either direction, or with the appropriate number of impulses. These depend upon what key of the board happens to be depressed by the person calling; and to create the proper effect the horizontal bar is furnished with studs which are arranged helicoidally. One key can alone at one time engage one contact, as the bar rotates. When this is effected, all the needles in the entire circuit move step by step to the number called, and there remain until the communication is finished, so that those which are not concerned may see that the circuit is engaged. When the needle has arrived at the desired number, the "calling" key is operated in order to ring the bell at that station. The key is a double current one, and when appropriately connected and operated can cause the armature of a magnet at the distant station to move backwards and forwards as desired. This movement brings a stud on the disc worked by the escapement up against the local bell contact. This stud is arranged differently in each station, so that the process of calling is selective. When the conversation is ended the key of "rest" is depressed at the original station, when the key at first used falls into its place, the clock-work begins to move, one of the springs or brushes comes into play at the distributor and sends alternate currents in number sufficient to bring back the needles of all the stations to their normal positions of "R," or rest. To secure that they take up these positions accurately there is a second electro-magnet, whose armature has a click, which prevents the disc, secured with the needle on the same arbour, from moving beyond the proper limits. E. O. W.

2372. *Chicago Telephone Company*. (West. Electn. 27. pp. 81–85, Aug. 11, 1900.)—This article describes with illustrations the fittings, technical arrangements, &c., of the main offices and exchange. The switchboard is of the common-battery relay multiple type. Present capacity 5,400, and space for extension up to 7,500 lines. The "A" or answering board is in 20 sections, each section having 7 panels, each panel 700 multiple jacks, each section having 3 operators' positions, and the greatest distance the operator has to reach being 3½ panels. One section contains jacks for all subscribers. Below the multiple jacks are placed the answering jacks for main subscribers, the number to each operator being apportioned according to the number of calls. The first 6 positions of the board are given up to measured-service lines, and each operator has about 160 answering jacks to attend to. The other positions on the board are devoted to unlimited-service lines, and as the calls are numerous no operator has more than 80 lines. The operation of the "A" or answering board is, briefly, as follows: When a subscriber removes his receiver from its hook, the line relay at the exchange closes, the lamp adjacent to the answering jack lights up, and the operator plugs in with her answering plug; in her cord is a third wire connected to a cut-off relay, which cuts out the line relay and extinguishes the lamp. She then connects over and rings in the usual way. When conversation is finished and receivers hung up the continuity of the battery circuit through the

subscribers' instruments is broken. This allows the disconnect relays in the cord circuit to release their armatures and break a shunt across the disconnect lamp signals, thus lighting these signals through the third wire. There is such a signal for each line. The operator can thus disconnect at the proper time, and, doing so, extinguishes the signal.

In the "B" or incoming-trunk board there are 13 sections, each section with 5 panels, and 2 operators' positions, and having all multiple jacks, each panel having 1,100 and space for 400 more. When a call comes in for a main subscriber the operator tests the line called for by tapping the tip of her plug on the rim of the multiple spring jack. If a click is heard, the operator inserts her plug into the "busy-back" jack, which sends back over the trunk line an interrupted buzz, thus giving notice to the calling subscriber as well as to the operator at the distant exchange, that the line called for is in use. If it is free the operator presses a push-button, which is latched and automatically sends an intermittent, alternating current to operate the distant bell. When the subscriber removes his receiver a battery-circuit is completed, actuating an armature which replaces the push-button, and he finds himself in communication with the caller. A lamp disconnect-signal appears when either the telephones are put back or the trunk line is disconnected. The operator then restores the cords to their places.

Each line of both boards has a 1-ampere fuse in its talking circuit, as has each operator's transmitter.

Each exchange has direct trunk lines with every one of the other exchanges, so that no trunking is done through a third exchange except in case of emergency. These trunk lines make up a vast network of wires, binding all the Chicago local exchanges into one complete system, and so systematic ard thorough is the working of the trunk lines that a subscriber experiences no appreciable delay when his call is for a number in a branch office other than the one in which his line is answered.

Among modern devices for anticipating every possible need and for saving time are two telephone-ringing dynamotors. These operate on a 220-volt circuit, and furnish alternating current for intermittently ringing the subscribers' lines, and supply the "busy-back" signalling current, the pulsating direct current for party line service, and also a "howler" current, which is used to vibrate rapidly a subscriber's receiver diaphragm when the receiver is left hanging, thus producing a "howling" sound and attracting attention. Also a compresser, driven by a 25-H.P. motor, for a pneumatic tube system used in cleaning out holes about the telephone switchboard, for compression tanks in the elevator system, &c. Fans for heating and ventilating are electrically driven. For the maintenance of the switchboard as well as for the benefit of the operators the air is washed, dried, and forced into the room, heated in cold weather and cooled in summer. It is washed by being forced through fine sprays of running water, and then circulated through tubes with spiral projections to free it of moisture. E. O. W.

2373. *Amsterdam Municipal Telephones.* (Electrician, 45. pp. 573–574, Aug. 3, 1900; from an article in "Municipal Affairs," by **P. Falkenburg** and **J. H. van Zanten.**)—A statistical article in which, among other details, the profits accruing to the municipality from the telephones are shown. There are 3,081 subscribers, a single exchange and one switchboard, horizontal and multiple, with a capacity for 10,800 lines. The overhead conductors are being placed underground and in the canals. There is already a considerable length of 28-pair and 56-pair cables. E. O. W

2374. *Blut's Telephone Sub-station System.* **Blut.** (Elektrotechn. Zeitschr. 21. pp. 318–321; Discussion, pp. 321–322, April 19, 1900.)—This system is chiefly designed for connecting a number of substations to a line communicating with an exchange-office, so that one or other of these substations can be connected to the line, and while so connected it is not possible to switch the other substations into circuit. For this purpose, each substation is provided with a special switch comprising two separable lever-arms oscillating about a common axis, and normally held together by a spring, one arm (*a*) bearing an armature and the other (*b*) a contact-piece adapted to be brought into or out of connection with the line; the arm *a* has an extension acted upon by a spring in such a manner as to hold the arms in an intermediate position, so that the armature on the one side of arm *a* is separated from its controlling electromagnet, and the contact on the other side of arm *b* is separated from the line. The upper or free end of arm *b* is V-shaped, and lies opposite a V-shaped projection on the spring-controlled hook-lever for the receiver, in such a position that, if the receiver is taken off its hook, the arm *b* will be moved so as to bring its contact into connection with the line; if, however, the electromagnet has previously attracted the armature, as described later, the arm *b* will be locked so as to keep it out of contact with the line. Above the hook-lever, and actuated thereby, is a lever (*h*) which, when the receiver is taken off the hook and the line contact made, connects a battery to a local circuit including the controlling electromagnets at all the substations on this line; if, however, the receiver at another substation has been previously removed, so that the arms *a*, *b* have moved towards the controlling electromagnet, the end of the arm *b* will engage the hook-lever and thereby prevent the lever *h* from moving far enough to complete the battery circuit at that substation. By these means, at any of these substations, by taking the receiver off the hook, it is possible to connect the instruments to the line, and at the same time prevent any of the other substations from being connected to line, the arms *a* and *b* separating at this calling station, when the electromagnets are energised. In order to enable the exchange to be put into connection with any one of the substations, one of the latter is arranged as a secondary exchange, and has its spring placed so as to hold the arm *b* normally in contact with the line. By these means, this secondary exchange will receive the call from the exchange proper, and can connect the desired substation to the line through a separate wire so as to enable it to be rung up by the exchange, the secondary exchange being simultaneously cut out of circuit with the exchange proper; on the subscriber at the desired substation taking the receiver off the hook, this substation is connected to the line as described above. At each substation there is an indicator showing whether the line is clear or not, *i.e.*, whether the armature has been attracted or not.

C. K. F.

REFERENCES.

2375. *Telephone Exchange Office in Berlin.* **Lindow.** (Elektrotechn. Zeitschr. 21. pp. 621–628, July 26, 1900.)—In this paper there is given a very detailed description, including dimensions, of all the apparatus at the new exchange office in Franzosische Strasse, which is capable of dealing with 10,600 subscribers' lines. Drawings and photographs are included in the original paper. C. K. F.

2376. *High-speed Telegraphy.* **Munier.** (Écl. Électr. 23. pp. 241–246, May 19 328–338, June 2; 367–376, June 9; 456–470, June 23; and 489–498, June 30, 1900.)—A description of various methods.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

DECEMBER 1900.

GENERAL PHYSICS.

2377. *Elasticity of Metals and Temperature.* **C. Schaefer.** (Deutsch. Phys. Gesell., Verh. 2. 11. pp. 122–126, 1900.)—The elasticity of metals is here investigated at very low temperatures, down to $-186°$ C., the boiling-point of liquid air. Both the longitudinal and torsional moduli are measured and the temperature coefficient of each is determined. The metals used were in the form of wires, and the same apparatus was used to determine both moduli. The lower scale-pan was supported by two rods from a cross-bar which was fastened to an aluminium tube surrounding the wire, the bottom of the tube being fastened to the lower end of the wire. The scale-pan, cross-bar, and tube were thus hanging on the wire and acted as a vibrator in the torsional experiments. The tube served to hold the cooling agents. One determination of the modulus of torsion was made for each wire by the vibrational method, and then the torsional static deflections under a constant couple at the various temperatures gave the temperature coefficient of torsion.

The results are:—1. The longitudinal and torsional moduli (η and k) between the temperatures $+20°$ and $-186°$ C. are represented by the equations—

$$\eta_t = \eta_{20}\{1 - \alpha(t-20)\}$$
$$k_t = k_{20}\{1 - \beta(t-20)\}$$

2. The temperature coefficient of the torsional modulus (β) is greater than that of the longitudinal modulus, and in consequence the lateral contraction μ increases with the temperature. 3. The greater the thermal coefficient of expansion, or the lower the melting-point, the higher is the temperature coefficient (gold forming an exception). 4. The elastic lag or hysteresis was measured in Al, Ag, and Cu. In all three it was approximately the same at ordinary temperatures, and at $-186°$ it was quite inappreciable. 5. The limits of elasticity were raised by lowering the temperature. 6. The lateral contraction may be expressed in the form—

$$1 + \mu_t = (1 + \mu_{20})\frac{1 - \alpha(t-20)}{1 - \beta(t-20)}.$$

The temperature calculated from this equation, which would give a value

of μ_t equal to $\frac{1}{2}$, is approximately the melting-point of the metal. This agrees with theory.

The author gives a comparison of his experimental results for temperature 20° with those of other experimenters. The following table gives his numerical results for the metals used.

Metal.	Mean Coeff. of Expansion between 0 and 100°.	k_{20} in kg. per mm².	Δk in % per 100° C.	η_{20} in kg. per mm².	$\Delta \eta$ in % per 100° C.	μ_{20}.	Melting-point.	
							Observed.	Calculated.
Platinum	$0 \cdot 0_5 907$	6,593	1·78	16,029	0·732	0·215	1,765	1,741
Palladium	$0 \cdot 0_4 1104$	4,613	2·696	11,284	1·979	0·223	1,578	1,724
Iron	$0 \cdot 0_4 1113$	7,337	3·035	18,347	2·250	0·247	1,500	1,470
Nickel	$0 \cdot 0_4 1279$	9,518	3·280	23,544	2·463	0·239	1,400	1,391
Gold	$0 \cdot 0_4 1454$	—	3·014	—	—	—	1,070	—
Copper	$0 \cdot 0_4 1698$	3,967	4·489	9,897	3·627	0·245	1,100	1,169
Silver	$0 \cdot 0_4 1900$	2,467	8·209	5,897	7·65	0·195	970	990
Aluminium ...	$0 \cdot 0_4 2336$	2,329	24·72	6,330	21·32	0·359	645	—
Zinc	$0 \cdot 0_4 2905$	1,614	48·37	4,296	—	0·331	419	—
Lead	$0 \cdot 0_4 2948$	550	78·67	1,493	—	0·431	327	—

J. B. H.

2378. *Natural Units.* **M. Thiesen.** (Deutsch. Phys. Gesell., Verh. 2. 11. pp. 116–121, 1900.)—Planck has shown that Wien's law furnishes us with two constants which, together with the constant of gravitation and the velocity of light, may be taken as the foundation of a new system of units which are independent of the properties of any particular body. [Abstract No. 497 (1900).] Thiesen considers that the formula given by Wien for the partition of energy in the spectrum of a radiating black body is not sufficiently substantiated for the constants which occur in it to be taken as the foundation of a new system of units, but he takes other constants, obtained from the laws of radiation connecting the total radiation and the wave-length of the maximum radiation with the temperature and applies these in place of the others. The five fundamental units are then the velocity of light, the constant of gravitation, the constant of electric attraction in Coulomb's law, and the above two constants of radiation. He then expresses other well-known physical constants in terms of these units by aid of their dimensions, and on substituting the numerical values obtains numerical relationships between the various constants, some of which agree closely with experimentally determined values. The constants thus treated are: The gas temperature-pressure constant; the elementary electric charge on an ion in electrolysis; Lorenz's degree of temperature, *i.e.*, the rise in temperature caused by unit of work applied to the number of atoms separated from an electrolyte by unit of electricity; Lorenz's constant or the heat conductivities of metals divided by the electrical conductivity and by the absolute temperature; and the relation between the charge and the mass of the particles in kathode rays. J. B. H.

2379. *Working Silica in the Oxy-gas Blowpipe Flame.* **W. A. Shenstone** and **H. G. Lacell.** (Nature, 62. pp. 20–22, May 3, 1900.)—The authors here give the results of their experience in making rods, tubes, and bulbs of various diameters of fused quartz.

Native masses of rock crystal are used. These are heated in a Bunsen

flame until the outer impure layers can be removed easily by a blow from an iron pestle or hammer. The clean masses of silica are then heated for some time in a vessel containing boiling water and dropped whilst hot into clean cold water. This treatment will cause the masses to crack to such an extent that they may easily be broken into fragments of convenient dimensions by sharp blows from a clean hammer. When the material has thus been broken up, the fragments are examined and all those containing foreign matter are rejected. The remainder are then heated to a yellow-red heat in a platinum dish and then quickly thrown into deep cylinders containing cold distilled water. The quartz has then the appearance of white enamel, and may be safely brought into the oxy-gas flame or be pressed against masses of white-hot plastic silica without preliminary heating.

Silica rods are made by joining piece to piece in the oxy-gas flame, care being taken to avoid enclosing air-bubbles by always fusing from below upwards. Tubes are made by binding a few rods round a small rod of platinum and fusing them together so as to form a rough tube; then after closing one end of this tube a small bulb is blown at its end. The bottom of the bulb is heated and a rod of silica attached. The whole bulb is then heated and drawn out into a tube.

Vitreous silica is less hard than chalcedony, but harder than felspar. Its surface hardness does not appear to be altered by any process of heating and cooling. Tubes may be cut by a diamond or by a file of hardened steel. The authors attribute the rotting of threads of silica to surface devitrification. This can be prevented, according to Gaudin, by heating to a suitable temperature. J. B. H.

2380. *Spiral-spring Balance.* **C. E. Linebarger.** (Phys. Rev. 11. pp. 110–111, Aug., 1900.)—A new form of Jolly balance is described in which the lower portion of the spring is brought to a fixed zero by moving its upper point of support up or down. A vertical tube fixed to a tripod contains a second tube sliding within it to which at its upper extremity is attached a cross-piece supporting the spiral-spring. This second tube has a millimeter scale attached, and is moved up and down by a milled head gearing with a rack. To the lower end of the spring is attached a piece of aluminium foil with zero mark, which moves in a short glass tube also with zero mark. The glass tube, which is attached to a clamp on the fixed tube, prevents excessive lateral or longitudinal motion of the spring. G. H. B.

2381. *Stop-clock for Atwood's Machine.* **W. C. Baker.** (Phys. Rev. 11. pp. 105–109, Aug., 1900.)—The clock is driven by a weight and regulated by a fan. A shaft rotating once in about 1½ seconds carries a wheel of 100 teeth, running loose on a sleeve on the shaft, to which is attached a pointer moving over a scale. Attached to the shaft is a light spring which presses on the face of the wheel with just enough friction to turn it with the shaft, but which slips as soon as a catch engages with one of the wheel teeth and holds it stationary. Two electromagnetic catches engage with the wheel; one releases the wheel (which is then turned by the clock-shaft) when the weight of the Atwood machine is released, and the other stops the wheel when the weight reaches the lower contact. G. H. B.

2382. *Modulus of Elasticity and Magnetisation.* **J. S. Stevens.** (Phys. Rev. 11. pp. 95–100, Aug., 1900.)—In previous papers the relation between magnetisation and the moduli of flexional and torsional elasticity has been

discussed [see Abstracts Nos. 202 and 1311 (1900)]. This paper deals with elasticity of traction and that of compression. A coil of wire was wound on a brass tube through which passed a stream of running water, in which was held the wire to be tested. One end of the wire was fastened to a rigid iron support and the other attached to a bent lever with a multiplying power of about 11. At the other end of the lever were attached weights which gave a tension on the wire of $5·39 \times 10^6$, $10·78 \times 10^6$, and $19·6 \times 10^6$ dynes respectively. The changes in length were communicated to another arm of the same lever, which multiplied the effect 110 times. The free end of this lever moved under the field of a micrometer microscope. Two wires were tested, each 175 cm. in length, and having diameters of 0·73 and 0·98 mm. respectively. The number of turns in the magnetising coil was 1,612, and the magnetising current was varied from 2·12 to 8 amperes in the different experiments. The conclusions obtained were as follows:—(1) The modulus of elasticity of traction increases when the body is magnetised. (2) The increase is fairly proportional to the magnetising force. (3) With the same wire the change in the modulus varies with the stretching weight. (4) With wires of different cross sections, stretched by the same load, the change in modulus is greater with the smaller wire.

In the experiments on the elasticity of compression a bar 134·5 cm. in length and 2·54 cm. in diameter was employed. The compression employed varied from 270 kilos. to 1,350 kilos. The magnetising current was varied from 0·5 to 23 amperes, the number of turns in the magnetising coil being 1,830. It was found that within the limits of this experiment magnetisation does not change the elastic modulus for compression. If it had been possible to apply a pressure nearer to that of the elastic limit of the metal the results might have been different. E. C. R.

2383. *Thermal and Electrical Conductivity of Soft Iron.* **E. H. Hall.** (Amer. Acad., Proc. 36. pp. 121–141, Aug., 1900.)—Full details are here given of the investigation, the result of which as to heat-conductivity is given in Abstract No. 2002 (1900). The iron experimented with was of density 7·785 at 0° C., and its percentage composition was Fe 99·93, C 0·059. The thermal conductivity was $0·1541\ (1 - 0·0003t)$, its specific conductivity was 0·0000817 at 18° C., and its thermo-electric quality as compared with copper ranged from 0·00001028 at 26·6° C. to 0·00000870 at 71·1° C. In the heat experiment the iron was used in the form of a disc with its faces heavily plated with copper and heated by flowing water. Platinum spirals were used to determine the temperatures, and an important discussion is the temperature-effect due to their copper leads. R. E. B.

2384. *Impact.* **J. H. Vincent.** (Cambridge Phil. Soc., Proc. 10. pp. 332–357, Aug. 13, 1900.)—If e_0 be the coefficient of restitution for an infinitely small velocity of approach and e the same for a given velocity u of approach, $e = e_0 - mu$; and the velocity of rebound is $e_0u - mu^2$, which has a limiting maximum value. The above applies to rubber balls at any velocity of approach; for a steel ball impinging on the plane surface of a lead, paraffin, brass or cast-iron block, e rises rapidly when the velocity of approach becomes small, but for large velocities of approach the above formula holds good. Hammering the surface of lead increases e. When non-deformable spheres impinge on plane surfaces of lead, paraffin, brass, or cast-iron with velocities of impact which are not too great, the square of the diameter of the dent is proportional to the velocity of impact; and for spheres of the same material

impinging with the same velocity, the diameter of the dent is proportional to the diameter of the sphere. When e is small (lead and paraffin) the time taken by any one sphere to produce a dent is independent of the velocity of impact, and the pressure (p) between the surfaces in contact is constant during this time (lead from 6×10^8 to 13×10^8 dynes/cm.^{2}; soft paraffin about 1×10^6 dynes/cm.^{2}). The volume of the dent is proportional to the energy of motion of the sphere just before impact. For steady loads the square of the diameter of the dent is proportional to the load; the pressure p between the surfaces in contact is constant and about one-half of p. The time of impact is directly proportional to the diameter of the impinging ball if other things be constant. A. D.

2385. *Surface-tensions of Homologous Series and Supercooled Liquids.* **J. Hock.** (Akad. Wiss. Wien, Sitzb. 108. IIa. pp. 1516–1528, 1899.)—Measurements by means of Jäger's apparatus (Sitzb. B. 100. IIa. p. 493) of the capillary-constants of the following liquids: Methyl, ethyl, propyl, butyl, and amyl alcohols, and formic, acetic, propionic, butyric, valeric, and caproic acids. The measurements for each liquid were made through a wide temperature range and *Brunner's law* (surface-tension a linear function of temperature) verified. No simple connection could be found between surface tension and chemical composition in the two homologous series investigated, and no break occurred in the curve for a supercooled liquid in passing through the melting-point. F. G. D.

2386. *Brown's Molecular Motions.* **F. M. Exner.** (Ann. d. Physik, 2. 4. pp. 843–847, Aug., 1900.)—Gum was dissolved in alcohol and precipitated by water, and the small particles so obtained were used for studying Brown's molecular motions. The motions were traced on smoked glass by means of Abbe's tracing device, and the distances traversed, divided by the time, gave the velocity of the particles. Such measurements were made for various temperatures and for particles of various diameters. Thus at a temperature of 23° a velocity of 0·0038 mm. per sec. was found in particles of 0·0004 mm. in diameter, 0·0033 mm. in particles 0·0009 mm. in diameter, and 0·0027 mm. in particles 0·0013 mm. in diameter. There is also a slight increase of the velocity with the temperature, but the temperature curve obtained indicates that all motion would cease at $-20°$ C. rather than at the absolute zero. The author supposes the motions to have some connection with the motions of the liquid molecules themselves, though the velocity of the latter is some 100,000 times greater. E. E. F.

2387. *Discontinuity in the Propagation of Explosive Phenomena.* **P. Vieille.** (Comptes Rendus, 131. pp. 413–416, Aug. 13, 1900.)—The author brings forward two hypotheses by means of which the high velocities of propagation of explosive phenomena can be explained. The first of these regards the explosion as composed of two parts, the reaction being produced by a preliminary rise in temperature due to the purely physical phenomenon of adiabatic compression of the medium which is considered as inert; the chemical part of the action merely modifies the composition of the medium in which the mechanical wave is propagated and maintains the high value of the condensation produced by the wave. The speed of propagation is hence that of a disturbance in the inert medium, and this cannot differ from the normal speed of sound in the medium until discontinuity sets in in the wave-front; as soon as this occurs a new elasticity comes into play, and this has a

higher value as the discontinuity of pressures on the wave-front becomes greater. The second hypothesis regards the medium as in a state of chemical equilibrium, and in this case the characteristic equation depends not only on two independent variables—temperature and volume—but also on the amount of combination of the mixture, which determines the chemical equilibrium of the variable system. The elasticity of such a medium, undergoing simultaneous chemical and physical transformation, may differ from the elasticity of the medium when inert, and consequently the speed of propagation of a disturbance may have a value different from the normal velocity of sound. But this theory requires that a variation in the chemical equilibrium should be produced by infinitely small variations of the volume and temperature, a condition not fulfilled by explosive gaseous mixtures, which can be compressed or raised in temperature to a high degree without any chemical change taking place. So that it is necessary in this case also to assume the creation of a discontinuity in order to explain the high speeds of propagation of explosive phenomena. T. H. P.

2388. *Electric Phenomena in the Euphrates Valley.* **E. Huntington.** (Monthly Weather Rev. 28. pp. 286–287, July, 1900.)—In the little-explored Taurus Mountains, south of Harpoot, peculiar electric phenomena are supposed to occur at rare intervals, perhaps three times in one year, generally in autumn after dry summers, and then not again for several years. They occur on mountains, varying in height between 5,500 and 7,500 feet, situated on both sides of the upper Euphrates, whose bed is about 2,000 feet above sea-level. The district is volcanic; hot springs and extinct craters are still to be seen. Lightning-flashes (or fire-balls) cross the valley between certain pairs of six peaks in either direction, but only between certain peaks, though the river winds a good deal, and the paths are consequently of very unequal length. The author has travelled in the district, but has not himself observed any such phenomena; he is inclined, however, to trust the reports of about a dozen men, living at different places many miles apart, because they agree in their accounts. H. B.

2389. *Fog Studies on Mount Tamalpais (San Francisco).* **A. G. McAdie.** (Monthly Weather Rev. 28. pp. 283–286, July, 1900.)—San Francisco is situated on a peninsula between the Pacific, the Golden Gate, and the Bay of San Francisco; Mount Tamalpais is a few miles to the north of the city. Fogs are regular in the afternoons of the summer months. The temperature on the ocean side may be 55°, and a few miles further inland 110°. The author tabulates meteorological data recorded in the city and on the Tamalpais Observatory, and reproduces three large-size photographs of fogs, streams, and banks. H. B.

2390. *Structure of Grains of Hail.* **P. Czermak.** (Akad. Wiss. Wien, Sitzb. 109. IIa. pp. 185–194, Jan.–March, 1900.)—The author exposed Plateau's drops of water to low temperatures. When water is introduced into a mixture of toluol (density 0·886) and chloroform (density 1·526), with an average density 1, the water assumes the shape of a sphere, which can be rotated if caught on a wire to which a small equatorial disc is fixed. As perfect symmetry is not easily maintained, the drops generally become elliptical, a form often shown by grains of hail. When a large water sphere is broken up into small globules, these latter will not reunite unless a stick of rubbed sealing-wax is approached, or an electric spark made to strike the

beaker in which the liquids are contained. If the water is allowed to run down the wire on to the disc, it will freeze to a convex lump, from which icicles project radially, which, with a disc 15 mm. in diameter, may reach a length of 12 mm. in fifteen minutes. These Plateau drops can be considerably under-cooled, especially when small, to -8° C., with drops 10 mm. in diameter. The author determined the temperature at which crystallisation finally sets in by dipping the point of a thermocouple into the sphere, supporting the latter by a wire ring smaller than the equator of the drop. A crust of ice is formed on the surface, from which needles project into the interior of the sphere. The portion which freezes is much smaller than it looks, only 0·12 of the whole, with drops cooled down to -10° C., and 0·06 of the whole with drops cooled to -5° C. This is in accordance with thermal considerations and calorimeter tests which the author made. The peculiar distribution of the air-bubbles in freezing water is also mentioned. H. B.

2391. *Anemometer with Oil Charge.* **A. Feoktistow.** (Zeitschr. Instrumentenk., Beib. 15. pp. 141–143, Aug. 1, 1900.)—The author discusses the difficulties experienced in keeping moisture out of the revolving mechanisms of cup anemometers. At Tajizy, near St. Petersburg, he uses an electric device of Richard Frères, contained in a cast-iron box fixed underneath the cup anemometer. In this device a worm slowly lifts the one arm of a lever to drop it suddenly; the other lever arm then strikes a spring bearing a platinum contact pin which is momentarily pressed against a platinum plate. After much trouble he filled the whole box of 1,400 c.c. capacity with vaselin-oil or petroleum by means of an Alveiler pump. Any water goes down the bend of a pipe, and is, if necessary, withdrawn, together with the oil, once every ten days. The oil does not interfere with the electric contact, and reduces the friction in the gearing, which is more disturbing than the inertia of the parts. He has not ascertained yet, however, whether the oil charge affects the constant of the instrument. The Leclanché cells are filled with calcidum (an ammonium chloride preparation which is said not to evaporate nor freeze). H. B.

2392. *Wind Pressure.* **R. Kohfahl.** (Zeitschr. Vereines Deutsch. Ing. 44. pp. 1021–1028, Aug. 4, 1900.)—After mentioning that the wind striking against the vertical cliff of Heligoland is deflected in such a manner as to produce a region of calm on the top near the edge, the author criticises the experiments on wind pressure which B. Baker conducted on the Forth Bridge in the years 1884 to 1890. The wind pressure became relatively smaller as the surface (struck normally) was made larger, but not in a regular way. For the relation between the wind pressure against a normal surface and a surface inclined under an angle α, we have five formulæ: the old Prussian architect's rule, von Lössl's, Rayleigh and von Gorlach's, Duchemin's and Hutton's. These formulæ differ considerably from one another, as the author exemplifies by tabulating the pressures for values of α, increasing by 5° from 0° to 90°. He deals particularly with Lössl's formula, $p_1 = p \sin \alpha$, as the simplest and most generally applied, and calculates the forces which would tend to upset right regular prisms. These forces increase with the number of sides of the prism, and attain their maximum value for cylinders, not however in the case of the formulæ of Duchemin and Hutton. The paper then proceeds to reproduce the monthly maxima of wind velocities at Hamburg for the years 1878 to 1898 as recorded by the Seewarte. The highest velocity of 35·6 m. was observed at noon on February 12, 1894. As those figures are derived

from hourly averages, the real values were probably higher; on the other hand, the recent determination of the constants of the instruments would reduce these values. All the great gales came from the S.W. or W.S.W., a few from N.W., hardly any from the E. The maxima for Wustrow, also quoted, situated in the east of Mecklenburg-Schwerin, on the Baltic, are, as a rule, higher (the situation is more exposed), though the Hamburg extreme is not quite reached, and the number of stormy days is greater; again S.W. winds predominate very strongly. From these figures the author calculates a normal wind pressure of 75 kg./m^2, and a maximum of 150 kg./m^2. Allowing further for the partial vacuum to the leeward of a structure, he concludes that pressures of 100 and 200 kg./m^2 respectively should be considered as normal and maximum for buildings of ordinary size. For high buildings much greater pressures must be allowed for; on the Eiffel Tower, at an altitude of 303 m., wind velocities have been observed five times as great as at the Central Meteorological Bureau, which has a height of 21·5 m. H. B.

2393. *Elastic Constants of Rocks and Velocity of Seismic Waves.* **H. Nagaoka.** (Phil. Mag. 50. pp. 53–68, July, 1900. Reprinted from the Publications of the Earthquake Investigation Committee in Foreign Languages, No. 4.)—Determination of Young's modulus and the modulus of rigidity of about eighty kinds of rocks. The amount of elastic after-yielding was in most instances very remarkable, and illustrates the folding of rocks. The author gives a tentative application of the results to the velocities of seismic waves, longitudinal and transverse. Deeply embedded rocks are denser and quasi-crystalline, but their coefficient of elasticity tends to assume large values. If the ratio (elasticity ÷ density) reaches a maximum value and then falls off, there will be a stratum of maximum velocity of propagation pretty deep in the earth's crust. Elastic waves must be greatly broken up, reflected, &c., in consequence of non-isotropism and want of uniformity in rocks. The first tremor has almost always a velocity of 13 kilometres per second, which is enormous: 5·3 in a rod of steel, 6·2 in infinite steel, 8·4 in iron pyrites, 9·0 in topaz. The low-lying rocks must have very high elastic constants: say $E = 6 \times 10^{12}$ when the density is 3·5. In iron pyrites $E = 3{\cdot}5 \times 10^{12}$. Between the first tremor and the principal shock comes a disturbance travelling at about 7 kilometres per second, which gives a ratio of lateral contraction to longitudinal extension much the same as that attributed to iron, glass, and other isotropic substances, if we take it that this disturbance is due to a transversal wave in the denser rocks at a depth below the surface. The principal shock travels slowly in surface rocks; average velocity 3 kilometres per second down to 1 kilometre, according to the rock. It will therefore arrive in successive reverberations according to the rocks it has passed through and the distance it has had to travel, and has been known to run round and round the earth and keep up a tremor for days. A. D.

2394. *Reports of the Earthquake Commission of Vienna. Earthquakes in Austria during* 1899. **E. v. Mojsisovics.** (Akad. Wiss. Wien, Sitzb. 109. I. pp. 151–313, Jan.–March, 1900.)—Summary of the various reports on earthquake observations throughout Austria (not Hungary) during 1899, chronologically arranged for each of the political divisions of the monarchy. The Commission of the Vienna Academy sends out inquiry sheets, and has interested particularly the schoolmasters and railway officials. The paper reproduces the abridged reports. Carniola and Görz were less disturbed than in previous years, while Dalmatia and Styria were more so than in previous

years. The total number of earthquake days was 190, against 209 in 1898. Their distribution over the year was: 22 days in January, 9, 12, 16, 17, 17, 20, 14, 21, 8, 17, 17 in the succeeding months. Most of them occurred in Alpine districts. The district of Sinj in Dalmatia, and the island of Lesina to the south of it, were much alarmed, especially on June 26 and the following days; no serious damage was done, however, anywhere in the state. In Carniola the Save-Laibach basin suffered most, as they did during Easter, 1895; the shocks of September 18 were felt over a length of 150 km. The area of the Tyrolese earthquake of April 5 coincides with the Valsugana cleft. Outside the Alpine districts the disturbances were limited to Upper Austria (especially on June 28), to subterranean detonations in the Duppau Mountains, Bohemia, on August 14; and to tremors at Kladno, Bohemia, on the night of June 3-4; the latter were probably not seismic, but arose in disused mines. There are four seismic stations—at Triest, Kremsmünster, Vienna, Lemberg; the latter two are not quite in working order yet.

The papers in the four following Abstracts refer to reports from some of the districts. The papers are illustrated by maps, not by curves. H. B.

2395. *Earthquakes in Upper Styria in April*, 1899. **R. Hoernes.** (Akad. Wiss. Wien, Sitzb. 108. 1. pp. 617-684, 1899.)—The disturbances of November and December, 1895, increased in 1899, and culminated in the shocks of the three days, April 1, 7, 29; the same districts and localities suffered on these three days; the intensity reached VI, Forel scale. None of these shocks extended into the usually much-disturbed Mürz valley, which leads in a north-easterly direction on to Wiener Neustadt; but they were all felt on the Palten-Liesing line, and particularly to the south-east in the crystalline slates and in the palæozoicum of Graz on the Mur. The latter feature is geotectonically surprising, but the same applies to the Kamp line. The centre seemed to be at St. Stephan, on the Mur (which afterwards changes its north-easterly course to a southerly course), situated some kilometres above Leoben, where many seismic lines intersect. The author recommends erecting an earthquake observatory at Leoben. H. B.

2396. *Earthquakes at Kremsmünster.* **P. F. Schwab.** (Akad. Wiss. Wien, Sitzb. 109. 1. pp. 19-68, Jan.-March, 1900.)—Kremsmünster lies a little south of Linz, in Upper Austria. The whole district is marked with disturbance lines. The paper chronicles earthquakes since 1511, describes the seismological station, which contains a Pfaundler seismoscope and an Ehlert seismograph, and gives detailed reports on the records of the latter instrument for 1899. The maximum for the year falls in the summer months (twenty-one disturbed days in July, not more than four in each month from October to January), and the day maximum in the afternoons. Variations in temperature, wind, and humidity do not explain the records, but barometric depressions, extending over large areas, might do so. H. B.

2397. *Earthquake in Lower Austria, June* 11, 1899. **F. Noë.** (Akad. Wiss. Wien, Sitzb. 109. 1. pp. 71-86, Jan.-March, 1900.)—This local earthquake was confined to the district between Vienna and Wiener Neustadt, which lie near the extremity of the Kamp line of Suess, and the country east of it, as far as the Neusiedler Lake. The seismic centre was near Pottendorf-Landegg, 16 km. N.E. of Wiener Neustadt; the maximum intensity (VI, Forel scale) was at Mittendorf. A large number of shocks were observed between midnight and 4 a.m. H. B.

2398. *Earthquakes at Triest, March to December*, 1899. **E. Mazelle.** (Akad. Wiss. Wien, Sitzb. 109. 1. pp. 89–138, Jan.–March, 1900.)—The paper tabulates the records of the triple horizontal pendulum of Rebeur-Ehlert. From the records taken between September, 1898, and December, 1899, the author finds that August (19·3 days) and February (17 days) are the months of greatest disturbance, and November (14 days) of least. Seismic disturbances are observed about every second day; amplitudes of 4 mm. and above occur every fourth day, and of 10 mm. every tenth day. The diurnal variations are regular; the frequency maximum falls in the early afternoon, the minimum about midnight. H. B.

2399. *Velocity of Meteors.* **W. L. Elkin.** (Astrophys. Journ. 12. pp. 4–7, July, 1900.)—The instruments in use at the Yale Observatory, U.S.A., have now been equipped with an arrangement by means of which the velocity of any meteors whose trails are photographed may be determined. Previous suggestions in this direction have been put forward by J. H. Lane in 1860, and by Zenker, of Berlin, in 1885. Quite recently it has again been referred to by Fitzgerald. The apparatus at present installed consists of a bicycle wheel carrying on its periphery a number of opaque screens, so adjusted that on rotating the wheel the lenses of the photographic cameras are covered during certain known periods of time. In actual practice about 30–50 revolutions per minute were obtained by means of a small motor, but the accuracy would be greater if the number of interruptions were increased. The wheel is automatically made to record its rotation on a chronograph barrel for accurate determination of speed. Two sets of apparatus must be employed at stations some distance apart. The Yale experiments were made at places about 3 kilometres apart. Examples are given of the deduced velocities of five duplicate trails already photographed, showing speeds from 32–40 kilometres per second with respect to the sun. C. P. B.

2400. *Suggested Explanation of the Solar Corona.* **J. Scheiner.** (Astrophys. Journ. 12. pp. 25–29, July, 1900.)—The absence of the dark Framhofer lines in the spectrum of the corona indicates that that structure cannot derive its light to any considerable degree from reflected sunlight. The idea that the coronal radiation may be due to the friction of meteoric matter falling into the sun is unlikely, considering the undoubted low density of the coronal matter. If the temperature assumed by a small perfectly black body at a certain distance from the sun's surface be calculated, values are obtained which have much probability of truth.

If q = quantity of heat radiated by an element of solar surface in unit of time,

ϕ = apparent semi-diameter of sun,

then the integral of the radiation upon an elemental area perpendicular to the line of sight will be—

$$W = \pi q \sin^2 \phi.$$

According to the most recent determinations the quantity of radiation received by the earth per minute per sq. centimetre is—

$$W = 4{\cdot}0 \text{ gramme calories, where } \phi = 16'.$$

At the distance corresponding to the outer ring of the corona the sun's semi-diameter would be about 45°, so that here the radiation received would be—

$$W = 4 \times 23083 = 92{,}332 \text{ gramme calories.}$$

Calculating the effective temperature, obtaining when the stationary condition is reached, from Stefan's law—

$$W = \sigma . T^4,$$

where T is the absolute temperature, and σ a constant whose value has been recently determined accurately by Kurlbaum as—

$$\sigma = 1{\cdot}28 \times 10^{-12} \text{ (unit of time} = 1 \text{ second).}$$

Hence the stationary temperature of an absolutely black unit of surface at the outer edge of the corona would be about—

$$T = 5890^\circ.$$

Correcting this for the fact that the receiving surface would not be plane, but approximately spherical, we get—

$$T = 4160^\circ.$$

This would be the extreme upper limit. Other constants might be used, involving the assumption of an existing atmosphere, but even in this case the effective temperature does not fall below 1,530°, and as this is still considerably above the temperature of incandescence, the author thinks there is no occasion to seek for any other cause of the continuous spectrum of the corona other than that of the direct radiation of the solar photosphere itself on an assumed collection of minute bodies in the region surrounding it. C. P. B.

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2401. *Quick-working Mercury Pump.* **Berlemont** and **Jouard.** (Comptes Rendus, 131. pp. 110–111, July 9, 1900; also Soc. Franç. Phys., Bull. 152. pp. 3–4, 1900.)

2402. *Ether Problems.* **J. Larmor.** (Elect. Engin. 26. pp. 339-341, Sept. 7, and 384–388, Sept. 14, 1900.)—The Presidential Address delivered before the Mathematical and Physical Section of the British Association.

2403. *Physical Tables.* (Bureau des Longitudes, Ann. pp. 487–628, 1900.)—A selection of useful tables, with explanations by **Damour, Berthelot, Cornu, Sarrau,** and others. A. D.

2404. *Scales of Seismic Intensity.* **C. Davison.** (Phil. Mag. 50. pp. 44–53, July, 1900.)—A careful comparison of the various scales of seismic intensity which have been proposed, and of the requisites of such scales. A. D.

2405. *Seismometrograph.* **G. Agamennone.** (Accad. Lincei, Atti, 9. pp. 31–39, July 15, 1900.)—Description of a new instrument of the horizontal pendulum type with a half-ton bob, and multiplying gear for the writing-point. A. D.

2406. *Solar Eclipse, May* 28, 1900. (Astrophys. Journ. 12. pp. 58–102, July, 1900.) —This paper gives in a condensed form the preliminary reports of the various observers occupying American stations during the late eclipse. Details of instrumental equipment, exposure, and many reproductions from the photographs obtained accompany the article. C. P. B.

LIGHT.

2407. *Relation of Brightness and Temperature.* **O. Lummer** and **F. Kurlbaum.** (Deutsch. Phys. Gesell., Verh. 2. 8. pp. 89-92, 1900.)—The radiation from a hollow platinum vessel is, with that of a platinum strip, passed through separate lenses on to the two faces of a Lummer-Brodhun photometer, the two platinums being made luminous by means of electric currents. The temperature of the hollow vessel is measured by a thermo-element when equal brightness is attained. Then, by means of a rotating sector, the brightness of the hollow vessel is diminished by a known amount, and photometric equality again obtained by raising the temperature of the vessel. If H_1, H_2, are the brightnesses of the hollow vessel at the respective absolute temperatures T_1, T_2, $\frac{H_1}{H_2} = \left(\frac{T_1}{T_2}\right)^x$, x depending on the temperature. The following values of x are found :—

T. abs.	900	1,000	1,100	1,200	1,400	1,600	1,900
x	30	25	21	19	18	15	14

The authors intend to determine the function x for a black surface; and then, by comparing both black and platinum surfaces with the sun, photometrically, an estimate of the sun's temperature can be made. G. E. A.

2408. *Scintillation and Atmospheric Currents.* **K. Exner.** (Akad. Wiss. Wien., Sitzb. 109. IIa. pp. 170-184, Jan.-March, 1900.)—A review of the researches of various physicists on the relation between atmospheric currents and scintillation, concluding with an account of several experiments by the author. The view is held that in the light from the fixed stars the wave-front is slightly disturbed from its plane form. Hence the rays, though but slightly changed from parallelism, pursue a wavy course and are at different places more or less closely packed in the beam than if not so disturbed. Thus a fluctuation of intensity arises. E. H. B.

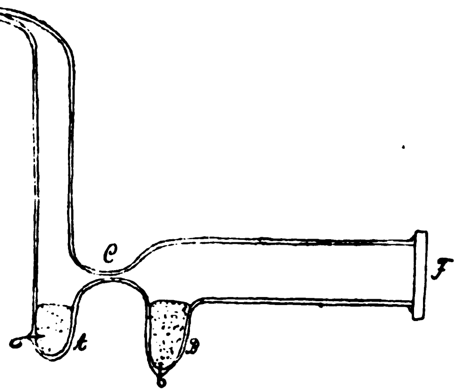
2409. *Colour Screen for Telescopes.* (Scientific American, 83. p. 186, Sept. 22, 1900.)—This is a small apparatus, due to T. J. J. See and G. H. Peters, which has been used to cut off some of the outstanding secondary spectrum from the images of celestial objects as seen with telescopes only corrected for two of the spectrum colours. Various combinations of coloured liquids were enclosed in a small glass tank placed between the eyepiece and the eye. Bichromate of potash, picric acid and chloride of copper, chromate of potash, and chromic acid were experimented with, the second solution yielding most satisfactory results. C. P. B.

2410. *Refractive Index and Alcohol-Solvent Power of Clearing and Mounting Media.* **C. E. M'Clung.** (Chem. News, 82. p. 88, Aug. 24, 1900. From the *Kan. Univ.* Quarterly, 7. No. 4.)—A table is given of the refractive indices (*for sodium light*) and clearing powers of a large number of oils and other

liquids used in microscopy; the clearing powers given represent the lowest strengths soluble in the reagent. Prices are also given where obtainable. Attention is called to oil of cassia, which has a refractive index 1·60160, clears from 80 per cent. alcohol, and dries hard enough to make permanent mounts. T. H. P.

2411. *Physiological Cold Light.* **R. Dubois.** (Comptes Rendus, 131. pp. 475–477, Aug. 27, 1900.)—The author obtains light by bacteria in suitable liquids. Such light has the well-known advantage that it is free from heat waves, and also has but slight chemical effect. The liquids should contain water, sea salt, glycerine or mannite, a nitrogenous body such as peptone or asparagine, and a compound of phosphorus such as lecithin or potassium phosphate. Asparagine is preferable to the peptones because there is less tendency to fermentation. No information is given as to the bacteria. The permanence of the light depends on the richness of the liquids, aeration, agitation, purity and temperature. It may continue for six months. The author has obtained illumination equal to strong moonlight. W. R. C.

2412. *Vacuum Tube with Mercury Electrodes for Zeeman Effect.* **F. Paschen.** (Phys. Zeitschr. 1. pp. 478–480, Aug. 4, 1900.)—The vacuum tube was designed to obtain an intense source of light for the special study of the complicated Zeeman effect observed by Michelson in the case of the mercury lines 5461 and 4359. The tube consists of a vertical and a horizontal portion (see diagram), at the junction of which two mercury cups A and B are connected by means of a capillary portion C. The bright line produced



in C is viewed end-on through the plate of fluorspar F. The cup representing the kathode is warmed so as to produce the proper pressure of mercury vapour. The constriction C is made to fit exactly between the rounded pole-pieces of an electromagnet. When the field is excited the line of light joining the electrodes increases greatly in brightness, and even surpasses in that respect the brilliance of a helium tube. Since no foreign gas is contained in the tube, the mercury remains perfectly clean. The life of the tube is, however, not very long, as it usually cracks near the anode after five or ten hours' use. E. E. F.

2413. *Compound Zeeman Effect.* **C. Runge** and **F. Paschen.** (Phys. Zeitschr. 1. pp. 480–481, Aug. 4, 1900.)—With the vacuum tube described in

the previous Abstract, the authors have observed the complicated Zeeman effect first described by Michelson. The green mercury line 5461 shows three central components whose electric oscillations are parallel to the lines of force. Then follow on both sides four further components, whose intensities decrease outwards, and whose oscillations are at right angles to the direction of the lines of force. Thus the single line is split up into eleven components. The line 4359 is split up into eight components. These two lines, 5461 and 4359, form two components of a triplet whose third component lies at 4047. It was therefore interesting to inquire whether a corresponding Zeeman effect could be obtained in the case of the third line. That was found to be the case. The next triplet of the series is formed by the lines 3341·7, 2893·7, and 2752·9. In the magnetic field they show the same modifications, and in the same succession, as the first triplet, except that in the first of them the extreme lines are no longer visible. In corresponding lines of each triplet the difference of frequencies is the same. E. E. F.

2414. *Focal Surfaces in Photographic Objectives.* **H. Harting.** (Zeitschr. Instrumentenk. 20. pp. 234–237, Aug., 1900.)—The author here criticises a paper by Wanach [Zeitschr. Instrum. 20. p. 161, 1900; Abstract No. 2175 (1900)], dealing, among other things, with the astigmatic focal surfaces in photographic objects. He also gives a solution of the problem by using Czapski's method, which he considers very much better than that used by Wanach. J. B. H.

2415. *Refractometry of Mineral Waters.* **E. Riegler.** (Chem. News, 82. p. 78, Aug. 17, 1900; Soc. de Sci. d. Bucuresci Romania, 9. p. 251, Nos. 2–3.) —The refractive index, which increases as the proportion of solid matter in a water increases, is suggested as a means of characterising mineral waters. A table is given of the indices of nineteen different waters, and it is found that the difference between the refractive indices of a mineral water and of pure water at the same temperature is independent of this temperature and of the adjustment of the Pulfrich refractometer employed. T. H. P.

2416. *Spectrum of Silicon.* **F. Exner** and **E. Haschek.** (Astrophys. Journ. 12. pp. 48–49, July, 1900.)—The authors have made measurements of the wave-lengths of the lines due to metallic silicon from photographs with a large Rowland grating, using the electric spark, and give values which confirm those given by J. Lunt, of the Cape Observatory, as occurring in the spectra of certain stars of the β Crucis type [see also Abstract No. 998 (1900)]. C. P. B.

2417. *Spectrum of Radium.* **E. Demarçay.** (Comptes Rendus, 131. pp. 258–259, July 23, 1900.)—A specimen of very pure radium, with barium lines very feeble, gave no lines beyond those already found [Abstract No. 55, (1900)], but some weak nebulous rays are much better marked. The spectrographic characters of radium are similar to those of the alkaline earths. A. D.

2418. *Spectra of Mercury.* **W. B. Huff.** (Astrophys. Journ. 12. pp. 103–119, Sept., 1900.)—The author has made a systematic study of the various spectra given by mercury vapour under different conditions, the importance of which had been suggested by previous work by Lewis on the effects of impurities in gaseous spectra [Abstracts Nos. 468 and 1798 (1900)]. Photo-

graphs were obtained with concave gratings of 21 feet and 7 feet radius. The arc spectrum was given by a direct current of about 10 amperes, while the spark and tube discharges were actuated either by an 8 cm. spark induction coil, or from a coil carrying alternating current in its primary from a Westinghouse dynamo making 130 complete oscillations per second. German soda-glass was used for the vacuum tubes. Numerous photographs are given showing the effect of introducing self-induction into the secondary spark circuit. C. P. B.

2419. *Lamps for Spectrum Analysis.* **E. Beckmann.** (Zeitschr. Phys. Chem. 34. pp. 593–611, Sept. 7, 1900.)—The author describes a new arrangement for obtaining coloured flames for spectroscopic work. The method employed consists in forcing air through the pores of a porcelain tube immersed in a solution of the salt to be examined, the finely divided gas impregnated with the solution then passing through a Bunsen flame. The vessel containing the solution is arranged between two burners placed obliquely so as to give a vertical flame above the surface of the liquid. With aqueous solutions the pressure necessary to force the air through the porous tube into the liquid is from 1·6 to 2 atmospheres, but with liquids having less surface tensions such as alcohol, acetone, or acetic acid, about half the above pressure suffices. A detailed description is given of the apparatus, which is now on the market. Another method of obtaining a stream of fine gas particles is by the electrolysis of the salt solution, but the difficulties of working have not yet been overcome in a satisfactory manner. T. H. P.

2420. *Velocity of Ions Produced by Röntgen Rays.* **J. Zeleny.** (Roy. Soc., Proc. 66. pp. 238–241, April 14, 1900. Also Roy. Soc., Phil. Trans. 195. pp. 193–234, Nov. 9, 1900.)—The velocity is determined for the positive and negative ions by comparing the ionic velocity directly with that of a stream of gas flowing between two concentric cylinders at different potentials, a narrow beam of Röntgen rays being passed through the cylinders at right angles to their length. The results given are reduced to a pressure of 760 mm. of mercury, but are not corrected for temperature, the effect of which is unknown.

Gas.	Velocity in cms. per sec. in a field of 1 volt per cm.		Velocity in cms. per sec. in a field of 1 E.S.U. per cm.		Ratio of negative to positive.	Temperature.
	+	—	+	—		
Air, dry	1·36	1·87	408	561	1·375	13·5 C.
Air, moist	1·37	1·51	411	453	1·100	14
Oxygen, dry	1·36	1·80	408	540	1·320	17
Oxygen, moist	1·29	1·52	387	456	1·180	16
Carbonic acid, dry	0·76	0·81	228	243	1·070	17·5
Carbonic acid, moist	0·82	0·75	246	225	0·915	17
Hydrogen, dry	6·70	7·95	2,010	2,385	1·190	20
Hydrogen, moist	5·30	5·60	1,590	1,680	1·050	20

G. E. A.

2421. *Production of Röntgen Rays.* **A. Winkelmann.** (Ann. d. Physik, 2. 4. pp. 757–767, Aug., 1900.)—When a spark-gap is introduced into a Röntgen ray circuit, the maximum gaseous pressure at which Röntgen rays

can be produced is increased. The author shows that the maximum pressure attainable depends upon the length and position of the spark-gap, the nature of the gas, and the dimensions of the tube. At the highest pressures, Röntgen rays only appear when the spark-gap lies between the kathode and the induction coil. As the pressure decreases, rays begin to appear also when the spark-gap is next the anode, but they are feebler than in the other arrangement. At low pressures, the influence of the position of the spark-gap becomes less pronounced and finally disappears. Hydrogen yields Röntgen rays at greater pressures than air or carbonic acid. The latter allows the least pressure, but its difference from air in this respect is not great. The admissible pressure may be considerably increased by making the tube narrower. Thus in a tube only 5 mm. in diameter it was found possible to increase the pressure of the air contained in it to 10 mm. of mercury and yet obtain effective Röntgen rays. But a further narrowing has the contrary effect, and in hydrogen the maximum pressure of 30 mm. is already reached in a tube 1 cm. in diameter. E. E. F.

2422. *Becquerel and Röntgen Rays.* **F. Himstedt.** (Phys. Zeitschr. 1. pp. 476–478, Aug. 4, 1900.)—The experiments described were chiefly made with one of Giesel's radium preparations. The author was able to demonstrate the influence upon an electroscope exerted by the preparation at a distance of 5 m. through the iron walls of the containing box. The stoppage of the play of sparks in a spark-gap attached to an influence machine was also strikingly shown. Röntgen rays produce the same effect, even at a distance of 4 m. To investigate the origin of radium rays, the author examined the behaviour of the preparation at the temperature of liquid air. But no diminution either of the effect upon a fluorescent screen or upon the discharging action was discovered, whereas Balmain's luminous paint was completely extinguished under the same circumstances. A number of experiments upon the visual perception of Becquerel rays showed that the perception of the rays is subject to rapid fatigue, probably owing to a continuous subsequent fluorescence of the humours of the eye. Blind people see the rays distinctly unless their retina is paralysed. Becquerel rays, Röntgen rays, and ultra-violet rays all reduce the resistance of a solenium cell. This is not due to the fluorescence of the latter, as no such fluorescence could be perceived. E. E. F.

REFERENCES.

2423. *Three Lens Objective for Telescope or Microscope.* **H. Harting.** (Zeitschr. Instrumentenk. 20. pp. 230–234, Aug., 1900.)—This paper forms another of the series of papers by the same author on the calculation of lenses for particular objects [see Abstracts Nos. 1844 (1899), 465 and 835 (1900)]. The present one deals with a three lens objective, the first and third lenses being of the same glass. J. B. H.

2424. *Ultra-violet Spark Spectra.* **F. Exner** and **E. Haschek.** (Akad. Wiss. Wien, Sitzb. 109. IIa. pp. 103–169, Jan.–March, 1900.)—The authors continue their examination of scandium and samarium [see Abstract No. 1993 (1900)]. S. R.

HEAT.

2425. *Vapour Pressure of Mercury.* **W. Müller-Erzbach.** (Deutsch. Phys. Gesell., Verh. 2. 11. pp. 127–136, 1900.)—Mercury in glass cylinders was placed in a widely open cupboard in a quiet room. Its surface thus remained clear for weeks. By finding the loss of weight and comparing this with the loss of weight of water under similar conditions the vapour pressure of the mercury was calculated, using a development of Graham's diffusion law, viz. :—

$$\frac{w_1}{w_2} = \frac{p_1}{p_2}\sqrt{\frac{d_1}{d_2}}$$

Where w_1, w_2 are the weights of evaporated liquids, p_1 and p_2 their vapour pressures, and d_1, d_2 their vapour densities.

Temp.	Duration of Experiment.	Loss of Weight.	Daily Loss of Weight.		Vap. Press. of Hg.
			Hg.	H_2O.	
	Days.	mg.	mg.	mg.	mm.
13·5	121	26	0·215	595	0·00124
14·5	30	7	0·233	651	0·00131
14·9	62	16	0·258	661	0·00147
16·6	41	14	0·341	726	0·00197
17·9	17	5	0·323	762	0·00193

The result for 16·6° is considered the best, and other observers' results are appended, the paper containing also the discussion of a number of results for other liquids. G. E. A.

2426. *Thermal Conductivity of Gases.* **P. A. Eckerlein.** (Ann. d. Physik, 3. 1. pp. 120–154, Sept., 1900.)—The thermal conductivities of air, hydrogen, and carbonic acid at low temperatures were determined by means of the thermometer method, the thermometric substance being petroleum ether. For air the conductivity k at $-59°$ was found to be 0·00003678 g/cm. sec., whereas k_{-150} was 0·00002146. From these two values we obtain $k_0 = 0{\cdot}00004677$ as against the latest theoretical value 0·0000455. For hydrogen the values were—

$$k_{-50} = 0{\cdot}0002393$$
$$k_{-150} = 0{\cdot}0001175$$
$$k_0 \ \ = 0{\cdot}0003186.$$

For carbonic acid, the value found was—

$$k_{-59} = 0{\cdot}00002645.$$

By Maxwell's law, which is known to hold good for CO_2, the value for k_0 would be 0·00003384. The experimental value is 0·00003434, thus showing a fair agreement. The conductivities of air and hydrogen do not increase in a linear manner from the absolute zero to ordinary temperatures, but the temperature coefficient gradually decreases, probably owing to molecular changes. In general, it may be said that Maxwell's theory is in good agreement with the facts. It is specially corroborated by the behaviour of carbonic acid at low temperatures. E. E. F

2427. *Influence of Molecular Volume on Gaseous Viscosity, II.* **G. Jäger.** (Akad. Wiss. Wien, Sitzb. 109. IIa. pp. 74–80, Jan.–March, 1900.)—In the formula for the viscosity, $\eta = k\rho c\lambda$, λ represents the path over which a molecule carries a definite amount of momentum. If the molecules may be taken as perfectly elastic they interchange their momenta on collision, so that λ exceeds the mean free path by a magnitude which at most equals the diameter s of a molecule, and which, by an approximate calculation wherein the speeds of all the molecules are taken as equal, the author finds to be $\frac{1}{2}s$ in the mean. Thus for the formula given in Abstract No. 75 (1900) we must write—

$$\eta = k\rho c\,(1 + 4\beta\mathrm{A})\,(\lambda_0\mathrm{A}^{-1} + \tfrac{1}{2}s),$$

where $\mathrm{A} \equiv 1 + \frac{5}{8}\beta + \ldots$; and since $\lambda_0 = 3/4\mathrm{N}\pi s^2$, $\beta = \frac{1}{6}\mathrm{N}\pi s^3$, this becomes—

$$\eta = \eta_0\,(1 + 4\beta\mathrm{A})^2/\mathrm{A}.$$

Hence for moderate densities the viscosity is $\eta_0(1 + \frac{11}{2}\beta)$, but for the liquid state it approximates to ∞, since A is then very large. R. E. B.

2428. *Law of Cailletet and Mathias and the Critical Density.* **S. Young.** (Phil. Mag. 50. pp. 291–305, Sept., 1900. Paper read before the Physical Society of London.)—Thirty substances have been examined by the author in order to test the law of the rectilinear diameter, due to Cailletet and Mathias, which states that the means of the densities of liquid and saturated vapour for any stable substance are a rectilinear function of the temperature. He has determined their mean densities at intervals of temperature of 10° between 0° and their boiling-points, as well as for higher temperatures. He finds that the law is nearly true, but not strictly true unless the ratio of the actual (D_c) to the theoretical (D'_c) density at the critical point has the normal value 3·77, as determined by Meyer's correction of the estimate of van der Waals. The formula $\mathrm{D}_t = \mathrm{D}_0 + \alpha t + \beta t^2$, where D_t, D_0 are the mean densities at $t°$ and 0°, and α, β are constants, is more accurate, and the values of α and β are determined for the thirty substances; for certain alcohols, however, it is necessary to introduce a fourth term, γt^3. The curvature of the "diameter" is generally smaller, the nearer $\mathrm{D}_c/\mathrm{D}'_c$ approaches the normal value, β being positive when $\mathrm{D}_c/\mathrm{D}'_c$ is less than 3·77, and negative when $\mathrm{D}_c/\mathrm{D}'_c$ is greater than 3·77, α being always negative. The curvature is so slight that the critical density may be calculated from the mean densities at temperatures from about the boiling-point to near the critical point by the simple formula $\mathrm{D}_t = \mathrm{D}_0 + \alpha t$ with small error; but if it be calculated by this formula from the mean densities below the boiling-point the error may be considerable, probably 5 or 6 per cent. for normal decane. The critical densities of the thirty substances, as calculated from the new formula, are given. As Guye has pointed out, the law does not hold at all for substances whose molecules differ in complexity in the gaseous and liquid states [see also Abstract No. 262 (1899)]. W. E. T.

2429. *Thermal Diffusivities of Marble.* **B. O. Peirce** and **R. W. Willson.** (Amer. Acad., Proc. 36. pp. 13–16, June, 1900.)—Determinations of the thermal conductivities of different kinds of marble were made by the so-called "wall method." The horizontal bases of a rectangular prism of height small compared with the area of a horizontal cross section were kept for a long time at constant temperatures, the final temperatures at two or more points in the vertical axis were determined, and the flux of heat through a definite central

portion of the colder base was measured. Besides the conductivities, the authors have also measured the specific heats of the different specimens tested, and their results are given in the following table :—

	Sp. gr.	Conductivity.	Avg. Sp. Heat (25° to 100°).	Sp. Heat per unit vol.	Diffusivity.
Carrara	2·72	0·00505	0·214	0·579	0·0087
Mexican Onyx	2·71	0·00556	0·211	0·572	0·0094
Vermont Statuary	2·71	0·00578	0·210	0·569	0·0102
American White	2·72	0·00596	0·214	0·582	0·0102
Egyptian	2·74	0·00623	0·212	0·581	0·0107
Sienna	2·68	0·00676	0·215	0·576	0·0117
Bardiglio	2·69	0·00680	0·218	0·586	0·0116
Vermont Cloudy White	2·75	0·00681	0·210	0·578	0·0118
Vermont Dove Coloured	2·74	0·00684	0·208	0·570	0·0120
Lisbon	2·75	0·00685	0·211	0·580	0·0118
American Black	2·68	0·00685	0·214	0·574	0·0119
Belgian	2·75	0·00755	0·206	0·567	0·0133
African Rose Ivory	2·75	0·00756	0·212	0·583	0·0130
Tennessee Fossiliferous	2·71	0·00756	0·214	0·580	0·0130
Knoxville Pink	2·73	0·00757	0·212	0·579	0·0131
St. Baume	2·70	0·00761	0·210	0·567	0·0134

J. J. S.

2430. *Radiation of a Black Body.* **O. Lummer** and **E. Pringsheim.** (Ann. d. Physik, 3. 1. pp. 159–160, Sept., 1900.)—In 1897 the authors had referred their thermoelectric measurements of the radiation of a black body to Holborn and Wien's normal couple. They have now reduced the temperatures to Holborn and Day's nitrogen thermometer [Abstract No. 2003 (1900)], and give a new table of temperatures of black bodies. E. E. F.

2431. *Heat-conduction within the Earth.* **J. Schubert.** (Phys. Zeitschr. 1. pp. 442–445, July 14, 1900.)—Riemann's theory is tested by comparison with the results of observation at Eberswalde and four other stations, the lag in phase of the "soil-heat below a depth" (defined by the integral $\int_x^\infty c\vartheta\, dx$, where ϑ is the temperature at the depth x and c is the specific heat of the soil per unit volume) behind the temperature at that depth being especially considered. In the theory c is assumed to be constant, but it must really vary with the season as well as with the character of the ground where the observations are made. Allowance, however, being made for this, the results of the comparison are satisfactory. R. E. B.

2432. *Theory of the Constant-volume Gas Thermometer.* **J. Rose-Innes.** (Phil. Mag. 50. pp. 251–260, Aug., 1900.)—The ordinary theory of the constant-volume thermometer introduces an arbitrary function of the pressure by integration along an isopiestic, which is determined by extrapolation to infinity from observations made in a small range. The author of this paper avoids the necessity for extrapolation by transforming the usual differential equation before integration. The formula arrived at is applied to the determination of the absolute value of the freezing-point of water, integration being effected between the limits of temperature, 0° C. and 100° C. The numerical

data are taken from the recent determinations by Chappuis of the increase of pressure of hydrogen at constant volume between these limits of temperature, from the measurements by Joule and Kelvin of the heating effect occurring when hydrogen passes through a porous plug, and from the determinations by Amagat of the relation between pv and p for hydrogen at constant temperature. The value thus found is in close agreement with the estimate derived by Kelvin from the constant-pressure air-thermometer.

In the case of hydrogen, nitrogen, and air the transformed differential equation is simplified by means of the characteristic equation of a perfect gas, the error thus introduced being shown to be only of the order of squares of small quantities; and the condition then is found that the constant-volume thermometer should give readings in accordance with the thermodynamic scale. The author also deduces the characteristic equation of a nearly perfect gas in the form—

$$p=\frac{Rt}{v-B}-\frac{\lambda}{v^2}$$

R, B, and λ being constants.

Attention is directed to the difference in theory between the methods of Joule and Kelvin of testing Mayer's hypothesis. The transformed differential equation of the paper exhibits the latter theory in a precise manner, and shows that the hypothesis would have been actually disproved if no change of temperature had occurred in the gas which passed through the porus plug.

W. E. T.

2433. *A Theorem Analogous to the Virial Theorem.* **Rayleigh.** (Phil. Mag. 50. pp. 210–213, Aug., 1900.)—The author, confining himself to the case of two dimensions, shows that, if m be the mass of the particle at the point x, y, and X, Y the components of force acting upon it, in any system—

$$2\Sigma m\frac{dx}{dy}\frac{dy}{dt}=\frac{d^2}{dt^2}\Sigma(mxy)+\Sigma(xY+yX),$$

the summation extending over all the particles of the system. Or, taking mean values with respect to time, if $\frac{d}{dt}\Sigma(mxy)$ does not continually increase, he obtains as in the case of the virial theorem—

$$2\Sigma m\frac{dx}{dt}\frac{dy}{dt}=\Sigma(xY+yX).$$

This equation seems applicable to the molecular theory of the viscosity of gases.

For statical problems it is of advantage to state the theorem in the following form:—In any system in equilibrium, if X, Y be the components of the total *external* force acting on the particle at the point x, y, and R be the force mutually operative between the particles at x, y and x', y', ρ being the distance between these particles and ϕ the inclination of ρ to the axis of x,

$$\Sigma(xY+yX)+\Sigma R\rho\sin 2\phi=0,$$

where the first summation extends to every particle and the second to every *pair* of particles.

Illustrations of the application of the theorem to frameworks are given and its utility in hydrostatical problems pointed out, the forces exercised by the containing vessel upon a liquid confined under hydrostatic pressure contributing nothing to the left-hand member of the equation. W. E. T.

2434. *Two Remarkable Groups of Geometrical Loci on the pv-Diagram.* **E. Mathias.** (Journ. de Physique, 9. pp. 479–487, Sept., 1900.)—From his experimental results for CO_2 Amagat has found that the locus of the points on a *pv*-diagram representing unit mass of the liquid and saturated vapour in equal volumes is a rigorously straight line nearly perpendicular to the *v*-axis. Mathias, *assuming* that the law of the straight diameter is exact (*i.e.*, that the mean of the densities of the liquid and saturated vapour for any the same temperature is a linear function of the temperature), concludes that Amagat's result is only approximate, and that the locus is really a curve A which is everywhere concave to the origin. [We might therefore, on the contrary, take Amagat's result as indicating that for CO_2 the law of the straight diameter is only approximate.]

Another result of the law of the straight diameter is that, of all the curves representing unit mass of liquid and saturated vapour in a constant mass-ratio, that one B alone meets the curve of saturation at a finite angle which corresponds to equal masses of liquid and vapour, and that this is convex towards the origin and touches the curve A at the critical point. This is true also for a certain other curve which is without physical signification, and the three corresponding curves on a *tρ*-diagram are analogously related. R. E. B.

2435. *Entropy Theory.* **J. E. Trevor.** (Journ. Phys. Chem. 4. pp. 514–528, June, 1900.)—The author calls attention to the relation between the thermodynamic temperature and the entropy of a system in the case of reversible additions of heat, as in all respects analogous to the potential theory in mechanics. He refers to a former paper of his own in the Journ. Phys. Chem. 3. p. 339, 1899 [Abstract No. 68 (1900)], in which he says he failed to establish the existence either of a uniquely determinate thermal potential or of the entropy function of any given thermodynamic system. In the present paper these results are obtained.

He first explains "the level theory," using a series of Carnot cycles, each of which may correspond to a given amount of work done or of heat used. The thermal potential corresponds to the energy of position in dynamics. The two principal definitions suffice to show the general nature of the reasoning.

Definition I.—The difference of thermal potential, corresponding to the difference of two given temperatures, shall be measured by the number of equal-work Carnot cycles in any series between the two temperatures.

Definition II.—The changes of "heat weight," or entropy of a system, shall be measured by the total work-value of the one-degree Carnot cycles, that correspond to the systems' simultaneous absorption of heat. Using θ to express the thermal potential as above defined, and η to represent the "heat weight" or entropy as above defined, he obtains finally the energy equation—

$$dE = dW + \theta d\eta,$$

where E denotes energy and W work. S. H. B.

REFERENCE.

2436. *Heat and Molecular Motion.* **Holzmüller.** (Zeitschr. Vereines Deutsch. Ing. 44. pp. 1080-1087, Aug. 18, 1900.)—The ordinary elementary explanation is here given of the phenomena of emission and absorption, and the elements of the kinetic theory of gases are also treated. J. B. H.

ELECTRICITY.

THEORY AND ELECTROSTATICS.

2437. *Theory of Potential.* **F. Hasenöhrl.** (Akad. Wiss. Wien, Sitzb. 108. IIa. pp. 1667–1693, 1899.)—The problem of finding the value of the potential at all points in space, when its value is given at each point on the surface of each of two spheres external to each other, was solved by Kelvin, who used the method of electric images. Hasenöhrl here treats the same problem by the older, or Murphy, method of spherical harmonics. Let the common diameter of the two spheres be taken for axis. Let a, a' be their radii, r, r' the distance of any point from their respective centres. Then, if P be a point external to both spheres, the potential at P due to any distribution which has the given potential V_a at all points on the sphere a can be expressed in the form—

$$\sum_{\mu=0}^{\mu=\infty} S_\mu \left(\frac{a}{r}\right)^{\mu+1},$$

where S_μ is a spherical surface harmonic of order μ, zonal about the common diameter. A similar expression holds for either sphere. Therefore—

$$V = \sum_{\mu=0}^{\mu=\infty} S_\mu \left(\frac{a}{r}\right)^{\mu+1} + \sum_{\mu=0}^{\mu=\infty} S'_\mu \left(\frac{a'}{r'}\right)^{\mu+1} + Q_1$$

Here Q_1 must satisfy Laplace's equation at all points external to both spheres, and at any point on the surface of either sphere must have an equal and opposite value to that due at the same point to the other sphere. Hasenöhrl now uses Q_1 for V, and so derives a new function Q_2 and so on. And by this means obtains the required function V in a convergent series. S. H. B.

2438. *Illustration of Poynting's Theorem.* **G. Mie.** (Zeitschr. Phys. Chem. 34. pp. 522–528, Sept. 7, 1900.)—The equipotential surfaces of electric force near a cylindrical conductor carrying a steady current are shown as long truncated cones surrounding the wire. The Poynting vector, viz., energy flowing per unit area per sec. =

$$\frac{\text{elec. motive intensity} \times \text{magn. intensity} \times \text{sine included angles}}{4\pi},$$

is then evaluated for a loop conductor passing through a plane, and is shown to be equal to the product of the current × the potential difference of the two points where the loop passes through the plane.

The case is then worked out of two parallel equal wires of great length, one pair of ends being at zero potential. Expressions are found for the electric and magnetic potentials and figures are given showing equipotential lines of electric and magnetic force in a section perpendicular to the wires, and the lines of flow of energy in a plane through the axis of the wires. Full particulars of the data used in the construction of the curves are given, and the author concludes that, especially for alternate currents, the Poynting theorem is necessary for a clear understanding of the electromagnetic processes. G. E. A.

2439. *Thermo-electric Theory.* **W. Voigt.** (Ann. d. Physik, 3. 1. pp. 155–158, Sept., 1900.)—The author criticises Liebenow's theory of the connection between thermal and electric currents [see Abstract No. 2016, (1900)]. He acknowledges that Liebenow's theory is in striking agreement with the facts, but that is only a kind of negative evidence for its truth. The chief objection to Liebenow's theorem lies in the ambiguity of the sign. In other theories where such an ambiguity occurs, it is due to the unknown numerical values of certain parameters. But in Liebenow's theorem the signs and values of all the constants are known, and yet there is an ambiguity of sign. Such a case is without a precedent in physics. E. E. F.

2440. *Elongation of Dielectrics in an Electrostatic Field.* **L. T. More.** (Phil. Mag. 50. pp. 198–210, Aug., 1900.)—Former experimenters on the change in length and volume of a dielectric when in an electrostatic field have always observed definite changes to take place, and some of them have represented these changes by formulæ. Röntgen in discussing the experimental results of Righi, Quincke, and others, and comparing them with his own, attributes the observed changes of volume and length to the electric compression of the electrodes and the heating effect of the electric charge. The present author has made careful experiments on the change of length, and has observed none to take place beyond the limits of experimental error, and certainly none approaching the changes of length observed by former experimenters.

The dielectrics used were glass and hard rubber tubes. The tube was placed between, and coaxial with, two vertical brass tubes. The three tubes were joined at the bottom by insulating material, and the spaces between them were filled with a liquid dielectric, having approximately the same specific inductive capacity as the glass or rubber tube being experimented on. This gave a uniform potential gradient between the two brass tubes, and so avoided any surface charges on the glass or rubber. The change of length was observed by means of a small optical lever, resting with two feet on the top of the inner brass tube, and with the third foot on the glass tube. One division of the micrometer eyepiece employed corresponded to a change of length of $1 \cdot 5 \times 10^{-5}$ mm., and quarter divisions could be read. Differences of potential of about 33,000 volts were used, and when the apparatus was adjusted so that no lateral motion of the top of the tube took place no elongation or contraction was detected.

It being supposed that the potential was not great enough, it was resolved to confirm the experiments of former investigators. The outer brass cylinder was removed, the space between the glass and inner brass cylinders was filled with acidulated water, and the middle of the outer surface of the glass cylinder covered with tinfoil. In no case was any elongation or contraction observed. A comparison with Righi's results shows that an elongation of at least ten divisions should have occurred.

The author attributes the experimental discrepancies to the methods used by Righi, Quincke, and others. The changes which these experimenters have observed he attributes to lateral distortions being recorded as changes in length owing to the system of rigid mechanical levers employed for magnifying. The author was greatly troubled by these lateral distortions and bendings, but they were always detected by a lateral motion of the field taking place simultaneously with the up-and-down motion.

The changes in volume which have been observed in liquid dielectrics, he attributes to changes in the form of the thermometer bulbs. J. B. H.

DISCHARGE AND OSCILLATIONS.

2441. *Pressure in the Electric Spark.* **E. Haschek** and **H. Mache.** (Astrophys. Journ. 12. pp. 50–51, July 1900.)—The authors reply to the criticism advanced by J. F. Mohler [see Abstract No. 108, (1900)]. That the pressure found by the latter should differ from their own result by as much as 45 per cent. they attribute to the different amounts of energy in the sparks under examination, which were produced by a transformer and a Ruhmkorff soil respectively. That the pressure is higher in illuminating gas than in air may be due to the fact that carbon was deposited from the gas upon the electrodes, and that the authors therefore really measured the pressure for carbon instead of brass. For carbon the observed spark pressure is indeed materially higher, and blackened electrodes give larger values than bright ones. The difference in the case of carbon dioxide may be accounted for by similar considerations. E. E. F.

2442. *Potential Gradient in Flame Gases.* **E. Marx.** (Ann. d. Physik, 2. 4. pp. 768–797, Aug., 1900.)—An apparatus is described which furnishes a gaseous pressure of about 0·1 atmosphere, constant to within 0·1 per cent. It is based upon the use of narrow capillary tubes. The pressure of the gas in the reservoir may alter considerably without sensibly affecting the velocity of efflux through the capillary tubes.

The potential gradient was measured between electrodes 17 mm. apart, the E.M.F. being furnished by 75 Clark cells. The temperature of the anode was varied by regulating the position of the flame. The object of the measurements was to find whether any acceleration of the positive ions could be attributed to a change of potential gradient produced by a reduction of the temperature of the anode. If the dissociation took place mainly within the volume of the flame, a change of the velocity ratio of the two kinds of ions would manifest itself in a change of the free charges. But such volume dissociation is only a part of the total dissociation, and the dividing line between the two kinds of dissociation cannot be definitely drawn. In any case, it is certain that the dissociation is not confined to the surface. E. E. F.

2443. *Dielectric Cohesion of Gases.* **E. Bouty.** (Comptes Rendus, 131, pp. 443–447, Aug. 20; 469–471, Aug. 27; and 503–505, Sept. 10, 1900.)—The value of the uniform field between condenser plates at which electricity first passes through the gas between the condenser plates measures the dielectric cohesion of the given gas at the given pressure. Assuming the field uniform at its centre, the critical potential gradient (volts/cms.) is y, which first decreases linearly with the pressure, passes through a minimum, and then increases indefinitely. Curves are discussed. Hydrogen is a worse insulator than air or CO_2 at high pressures, but a far better one at very low pressures. The critical fields here studied are analogous to those in which sparks pass, but are not identical, for here it is a question of currents, not of visible sparks. Where in hydrogen for currents the critical potential gradient $\gamma = 1{\cdot}4 + 68{\cdot}38\,p$, for sparks $y = 62 + 65{\cdot}09\,p$ (Wolf). The term proportional to the pressure is common to both: the first term depends on the work done at the surface bounding the gas, which work is not nil, even with vacuum discharges. Water vapour in itself and apart from deposited films of moisture, is a perfect insulator. As between different gases, the critical value of the potential gradient for the passage of currents presents an absolute term which is nearly the same for all, and a term proportional to the pressure the coefficient for

which varies from gas to gas; but this coefficient does not seem clearly related either to the mean free path or to the specific inductive capacity. A. D.

2444. *Phosphorus Exhalations.* **C. Barus.** (Phys. Rev. 10. pp. 257–267, May–June, 1900. Paper presented to the Smithsonian Institute.)—By an electrical method (condenser leakage) it is ascertained that the rate of discharge of a freshly charged condenser, with air between the plates laden with phosphorus exhalations, is not discernibly different before and after an interval of nearly three hours; and the ionising potency of the phosphoric source does not appreciably diminish during comparatively short intervals, say fifteen minutes. But some kind of polarisation or counter current seems to be suggested by the falling off in saturation as we recede from the phosphorus. There appear definitely to be no obscure radiations accompanying the ionised particles exhaled by phosphorus, which are stopped by any mechanically impermeable medium and pass sometimes in very small, sometimes in larger proportion through porous papers. When they do pass the permeability dimimishes with lapse of time, as if deliquescing phosphoric acid clogged the pores. A. D.

2445. *Emission of Kathode Rays at Zero Potential.* **C. E. S. Phillips.** (Electrician, 45. pp. 773–774, Sept. 14, 1900. Abstract of a Paper read before the British Association.)—The green flecks produced upon the inner walls of vacuum bulbs by the action of kathode rays may be made to rotate by mounting the kathode upon a pivot and making it turn by some magnetic contrivance. It is found that the flecks persist even after either or both of the electrodes are connected to earth, and continue to rotate with the kathode. When a piece of metal is placed in a rarefied atmosphere, and made the negative pole for an electric discharge, innumerable small bright specks of light appear over the surface of the metal. The author used iron electrodes in order to be able to magnetise them, and to control the magnetic field. The latter made visible the lines of light emerging from the specks, and bent them in the well-known spiral manner. The number of jets becomes smaller as the exhaustion is continued, and finally the specks on the kathode disappear, while the green patches on the wall become brighter. The streams of gas lead to the deterioration of the vacuum. After the electrodes have been put to earth, the jets of gas continue to emerge, and are sufficiently ionised to produce green fluorescence. It is remarkable that fluorescence should continue to be produced when the velocity of the kathode particles has fallen below a limit which the author estimates as being the velocity of sound in air. E. E. F.

2446. *Mechanical Effects of Kathode Rays.* **H. Starke.** (Ann. d. Physik, 3. 1. pp. 101–107, Sept., 1900.)—Experimental determinations of the force exerted by kathode rays upon light movable bodies are as yet lacking, though Riecke has estimated the force acting upon a kathode shaped like a propeller. If the force thus found is regarded as that due to the reaction of projected particles, an amount of energy results which surpasses the whole energy of the kathode rays. It is, therefore, not permissible to deduce the kinetic energy of the kathode particles from such experiments. The author has adopted a different arrangement. He used a kathode with a number of plates resembling a propeller. But the kathode was kept fixed, and the kathode rays impinged at an angle of 45° upon a thin plate of aluminium

suspended above the kathode by means of a thin platinum wire. The results were almost all negative. An influence machine gave nothing but irregular disturbances, probably due to electrical forces unconnected with the impact of kathode rays. An influence machine of 20 plates, yielding a discharge potential of 10,000 volts, and a current intensity of 10^{-7} amperes, gave something like an appreciable deflection, which indicated, however, that the force to be measured is below 10^{-4} dynes. The experiments are to be continued.
E. E. F.

2447. *Reflection of Kathode Rays.* **H. Starke.** (Ann. d. Physik, 3. 1. pp. 75–100, Sept., 1900.)—Two years ago the author described a study of the diffused reflection of kathode rays, and showed that the reflected rays take their charges with them [see Abstract No. 87 (1899)]. He has since repeated the experiments with greater precautions, and has studied more especially the reflective powers of copper and aluminium for kathode rays. Mirrors made of the two metals were placed inside a metallic cylinder, through an opening in which the kathode rays entered. A galvanometer connected with the mirror measured the amount of kathode radiation absorbed. The amount reflected and diffused was measured by nearly surrounding the mirror with a second cylinder fitting in the first, and connected with another galvanometer. The two metallic cylinders were enclosed in a vacuum together with the kathode furnishing the rays. The mirror was put into two different positions in the cylinder, so as to determine the amount of kathode radiation diffused by the gas itself. The reflective power of aluminium was found to be 28·2, and that of copper 45·5, whatever the velocity of the kathode rays.

The author also devised a method of readily exchanging reflectors, and thus comparing the reflective powers of two metals without having recourse to absolute measurements. Taking the same value of 28·2 for aluminium as a basis, the reflective power of copper came out as 45·1. E. E. F.

2448. *Anode and Kathode during Discharge.* **K. Przibram.** (Akad. Wiss. Wien, Sitzb. 108. IIa. pp. 1161–1171, 1899.)—Comparison of discharges under varied conditions. The conclusion arrived at is that the discharge begins later at the positive pole and spreads out more rapidly than that at the negative. A. D.

2449. *Passage of Ions in Gases.* **J. S. Townsend.** (Nature, 62. pp. 340–341, Aug. 9, 1900.)—Negative ions which are produced in air by the action of Röntgen rays will produce other ions when they move through the gas with a velocity which is small compared with the velocity of light. The conductivity of the air is increased by the additional ions thus formed. A. D.

2450. *Projection of the Ether.* **P. de Heen.** (Phys. Zeitschr. 1. pp. 473–474, Aug. 4, 1900. From Archives de Genève, 9. and Bull. Acad. Roy. Belgique, 1899, p. 589.)—The author regards kathode rays as projections of the ether itself from the kathode. These projections carry material particles along with them, and can therefore exert mechanical force. When the rays impinge upon an anti-kathode, the material particles penetrate into the substance of the anti-kathode, and the rays, freed from their entanglement with matter, are better able to penetrate the walls of the tube and form Röntgen rays. The ether projections are brought into connection with the solar corona and the tails of comets. E. E. F.

2451. *Electromagnetic Waves and Diffraction.* **A. Lampa.** (Akad. Wiss. Wien, Sitzb. 108. IIa. pp. 786–802, 1899.)—Experimental and mathematical discussion of maxima and minima, with a total reflexion grating. The index of refraction of paraffin is found to be 1·44 for long waves. A. D.

2452. *Periodicity in Electric "Touch" of Chemical Elements.* **J. C. Bose.** (Roy. Soc., Proc. 66. pp. 450–451, Aug. 4, 1900.)—The phrase *electric touch* is here used in the restricted sense of sensitiveness to electric radiation, the touch being regarded *positive* when there is a diminution of resistance by the action of radiation, and *negative* when radiation produces an increase of resistance. A systematic inquiry into the action of nearly all the elements, including the metalloids and non-metals; also of some alloys, amalgams, and compounds, has led to the following hypotheses:—(1) That the contact sensitiveness depends on the chemical substance. (2) That the sensitiveness of an element is a periodic function of its atomic weight. (3) That the effect of radiation is to produce a molecular change or allotropic modification of the substance acted on, so that a positive substance becomes less positive, and a negative substance less negative. The change may in certain cases produce actual reversal. (4) That the so-called "fatigue" is due to the presence of radiation products. E. H. B.

2453. *Electric "Touch" and Molecular Changes produced by Electric Waves.* **J. C. Bose.** (Roy. Soc., Proc. 66. pp. 452–474, Aug. 4, 1900.)—This paper describes a number of experiments upon electric *touch* or contact-sensitiveness to electric radiation. From these the following conclusions are drawn: —(1) That ether waves produce molecular changes in matter. (2) That the molecular or allotropic changes are attended by changes of electric conductivity, and this explains the action of the so-called coherers. (3) That there are two classes of substances, positive and negative, which exhibit opposite variations of conductivity under the action of radiation. (4) That the production of a particular allotropic modification depends on the intensity and duration of incident electric radiation. (5) That the continuous action of radiation produces oscillatory changes in the molecular structure. (6) That these periodic changes are evidenced by the corresponding electric reversals. (7) That the "fatigue" is due to the presence of the "radiation product," or second allotropic modification. (8) That by means of mechanical disturbance or heat, this product can be transformed into the normal form, and the sensitiveness may thereby be restored. E. H. B.

2454. *Lecture Experiments illustrating Syntony.* **P. E. Shaw.** (Phil. Mag. 50. pp. 283–290, Sept., 1900. Paper read before the Physical Society of London.)—Following upon the work of Lodge [see Abstract No. 960 (1899)], the author devised experiments to illustrate in a lecture the use of syntony in magnetic space-telegraphy. The space over which it was desired to transmit the signals is here reduced to that of the lecture-room, but the receiver is required to make the result audible to an audience. The details of the problem were therefore quite different from those involved in signalling over greater distances to a single observer. The very considerable difficulties encountered were, however, finally overcome. The paper gives a summary of the theory involved, a full description of the sending and receiving circuits, and the precautions to be observed in manipulating the apparatus. E. H. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

2455. *Resistance of Electrolytes in Motion.* **J. Nabl.** (Akad. Wiss. Wien, Sitzb. 108. IIa. pp. 1535–1558, 1899.)—This is an extension of the work of J. Bosi (Il Nuovo Cimento, ser. iv., tom. v.) on the change of resistance of electrolytes when moving rapidly either with or against the current. No change in resistance could be observed in the case of potassium hydroxide or hydrochloric and sulphuric acids when moving at 7 m. per minute with or against the current; and in entire contradiction to Bosi's results, no change could be detected in the case of zinc sulphate, copper sulphate, or potassium chlorate, either with a sensitive d'Arsonval galvanometer, or with a capillary electrometer as used by Bosi. The changes observed by Bosi differed in magnitude according to the direction of the stream, and are not therefore in agreement with any of the recognised theories of electrolysis, whereas the absence of any change, although a negative result, is in agreement with Hittorf's theory. The origin of the contradictory results of the two observers has not been ascertained. T. M. L.

2456. *Electrolytic Conduction in Vapours.* **A. Hagenbach.** (Phys. Zeitschr. 1. pp. 481–483, Aug. 4, 1900.)—To study the change of conductivity in vapours at the critical temperature, the author used solutions of sodium bromide or iodide in sulphurous acid. The resistance of the solution increased with the temperature, the increase being accelerated towards the critical temperature. But in all cases the conductivity had a small finite value at the critical temperature. On further heating the resistance increased, but more slowly. That was the course of events when the electrodes were immersed in the liquid. On inverting the tube, so that the electrodes were above the surface of the liquid, the resistance was infinite until close upon the critical temperature. At that temperature it reached a minimum, after which it rose again. The existence of a maximum conductivity at the critical temperature proves the existence of electrolytic conduction in vapours and gases. A further proof is afforded by the existence of a small though distinct polarisation. The electrical method is a valuable addition to the existing methods of studying the critical points. The critical temperature is always increased by the addition of a salt. In the author's experiments it ranged from 156° to 170°. E. E. F.

2457. *Electrocapillary Functions of Aqueous Solutions.* **Gouy.** (Comptes Rendus, 131. pp. 255–258, July 23, 1900.)—Discussion of curves of h (=height of mercury in a capillary electrometer) and Δ (= L | Hg, in volts at the meniscus), with different solutions and liquids L. The part of the curve where the slope is positive, and as far as a little way beyond the maximum, depends almost entirely upon the anion; the rest of the curve varies little, and depends chiefly on the kation. A. D.

REFERENCE.

2458. *Electromagnetic Theories.* **H. A. Lorentz.** (Phys. Zeitschr. 1. pp. 498–501, Aug. 11; and 514–519, Aug. 18, 1900. Address to the University of Leyden, Feb. 8, 1900.)—A review of the influence of electromagnetic theories, especially Clerk-Maxwell's, in directing research and in contributing to the progress of physical science, with reference, among others, to Hertz's work and to Zeeman's.

G. E. A.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

2459. *Action of Chlorine on Metallic Silver in the Light and in the Dark.* **V. v. Cordier.** (Akad. Wiss. Wien, Sitzb. 109. IIb. pp. 540–555, June, 1900.) —The influence of light on the decomposition of silver compounds has been the subject of many investigations, but the formation of these compounds under similar conditions seems not to have received attention. A number of experiments on the action of chlorine on silver under different conditions of illumination are described in the paper; for details of the apparatus and methods employed the reader is referred to a previous communication (Monatshefte für Chemie xxi., 184–199, 1900). The following conclusions are arrived at:—Red light has no influence on the production of silver chloride, whilst blue and violet light favour the formation of the compound. Light which has filtered through a sufficiently thick layer of chlorine behaves like red light. The activity of white light is diminished much more by passage through moist, than through dry, chlorine. Admixture of small quantities of hydrogen with the moist chlorine still further diminishes the activity of light in promoting chemical action. The action of chlorine on silver is practically uninfluenced by Röntgen rays.

Similar experiments with bromine and silver are in progress. N. L.

2460. *Action of Sodium Hydroxide on Benzaldehyde.* **C. Pomeranz.** (Akad. Wiss. Wien, Sitzb. 109. IIb. pp. 283–300, March and April, 1900.)—The reaction between sodium hydroxide and benzaldehyde proceeds according to the equation—

$$2C_6H_5CHO + NaOH = C_6H_5COONa + C_6H_5.CH_2.OH,$$

and is hence a reaction of the third order. The author finds that the velocity constant of the reaction (calculated from the equation—

$$8Kt = 1/(a-x)^2 - 1/a^2,$$

a representing the initial quantity of sodium hydroxide and x the amount of it decomposed after the lapse of the time t) decreases as the reaction proceeds, this decrease being more marked in the case of concentrated solutions. By making use of the method proposed by Ostwald and van't Hoff for determining the order of complicated reactions, the concentration of the benzaldehyde being made very great compared with that of the sodium hydroxide, it is found that the concentration of the alkali enters into the differential velocity-equation in the second power, which would make the reaction one of the fourth order. The velocity constants calculated on this assumption are, when the reaction proceeds rapidly—with concentrated solutions and especially at the commencement—in much better agreement than the values for a reaction of the third order, but these latter hold better for dilute solutions. This apparent contradiction the author explains by supposing the reaction to occur in two distinct phases—

$$(1)\ 2C_6H_5.CHO + NaOH = (C_6H_5CHO)_2NaOH$$
$$(2)\ (C_6H_5CHO)_2NaOH = C_6H_5COONa + C_6H_5.CH_2.OH;$$

the formation of such an addition compound is supported by the existence of

similar bodies. The first of these two phases, which is of the third order, proceeds much more rapidly in concentrated than in dilute solutions, while the decomposition of the addition product will occupy a time which is independent of the concentration. Taking into account the fact that the addition product differs from sodium hydroxide and benzoate in not being ionised in solution, the author shows that in the case of concentrated solutions, the differential equation for the velocity of reaction is of the fourth degree. T. H. P.

2461. *Ultra-violet Absorption of Closed Chain Carbon Compounds.* **W. N. Hartley** and **J. J. Dobbie.** (Chem. Soc., Journ. 77. and 78. pp. 846–850, July, 1900.)—Measurements are given of the absorption spectra of 2:5-dimethylpyrazine, hexamethylene and tetrahydrobenzene in alcoholic solutions. The last two compounds show no selective absorption, thus confirming the conclusion that the banded spectrum is shown only by substances which possess the true benzenoid structure. T. H. P.

2462. *Partially Miscible Aqueous Inorganic Solutions.* **G. S. Newth.** (Chem. Soc., Journ. 77. and 78. pp. 775–778, July, 1900.)—On shaking concentrated ammonia solution with a saturated solution of potassium carbonate, the liquid separates into two layers, consisting of a saturated solution of the two solutions in one another. At ordinary temperatures, the potassium carbonate solution dissolves about 37 per cent. by volume of the ammonia solution, which in its turn takes up about 6 per cent. of the carbonate solution. These proportions increase with rise of temperature until the compositions of the two layers become identical, the liquids, at this critical temperature, being miscible in all proportions. The critical temperature is greatly influenced by the addition of small quantities of water, 6·9 per cent. of water added to the mixture sufficing to reduce it from 43° to 25°; similarly on dissolving anhydrous potassium carbonate in concentrated ammonia, the critical temperature of complete miscibility of the two layers is higher than when a saturated solution of the salt is employed. T. H. P.

2463. *Persulphuric Acids.* **T. M. Lowry** and **J. H. West.** (Chem. Soc., Journ. 77. and 78. pp. 950–961, July, 1900.)—Results are given of a study of the equilibrium of the system—sulphuric acid, water, persulphuric acid, hydrogen peroxide—the curve obtained being very similar to that corresponding with the equation—

$$C_1C_2 = 12{\cdot}6(C_3/C_4)^4,$$

where C_1, C_2, C_3, and C_4 represent the relative molecular proportions of the persulphuric acid, hydrogen peroxide, sulphuric acid, and water respectively. Assuming that the chief product of the interaction of sulphuric acid and hydrogen peroxide is a persulphuric acid of the series H_2O_2, $n\,SO_3$, it must be the fourth member having the formula H_2O_2, $4SO_3$. The deviations of the experimental curve from that deduced from the equation of the fourth order given above point to the formation of a small quantity of a lower acid of the same series, probably H_2O_2, $2SO_3$, which Berthelot assumed to be the sole product of the reaction. T. H. P.

2464. *Migration-Constant of Sulphuric Acid Mixtures from Measurements with Lead-Accumulators.* **A. Kendrick.** (Zeitschr. Elektrochem. 7. pp. 52–56, Aug. 2, 1900.)—Sulphuric acid concentration-cells with electrodes of Pb or

PbO_2 were measured. These measurements were combined with similar ones obtained with a concentration-cell (sulphuric acid) containing hydrogen-electrodes. Working in this way and employing very small concentration-differences, formulæ can be obtained which give the migration-constant of the H-ion in terms of the small E.M.F.'s measured, the other factors being eliminated, since the same concentrations were used both in the lead and hydrogen cells. The author gives tables showing how the values of the migration-constant so obtained vary with the concentration of the acid, and compares his results with those of previous workers in the same field. For numerical details reference must be made to the original paper. F. G. D.

2465. *Potential Fall and Dissociation in Flame-Gases.* **E. Marx.** (Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 1. pp. 34–67, 1900.)—The departures from Ohm's law in flames under low E.M.F.'s are well known. Through the study of flame-conduction in a magnetic field we find that besides apparent departures due to saturation-current there is a true abnormality at low E.M.F.'s. The concentration of ions in a flame is a function of the temperature of the electrodes and falls as the temperature falls. If the temperature of the anode falls below a certain limit the positive ions undergo accelerations such that under approximately equal P.D.'s the curve of potential slope becomes approximately symmetrical and horizontal at its mid-course; and as the temperature falls still farther, the potential slope preponderates towards the anode instead of towards the kathode. With electrodes at the same temperature accelerations of the negative ions may present themselves at as low as 2 volts potential difference. The quantity of free positive electricity at the kathode falls off and the free negative charge at the anode increases as the anode cools down. The degree of flame-dissociation for the positive or for the negative ions depends upon the temperature of the corresponding electrodes. In a flame the points where unipolar conduction disappears are on isothermals. The slope of potential indicates by its variations the relative velocities of the ions. Arrhenius's observation that dissociation in a flame is electrolytic is apparently at variance with Coulomb's law, and appears explicable by attributing the electrolytic dissociation to the electromagnetic resonance of OH ions under ultra-red radiation, so that it is to be attributed to the somewhat accidental presence of these ions and their own proper electromagnetic note, not to any dissociating force in the flame. [See also Abstract No. 2442 (1900)]. A. D.

2466. *Difference of Potential between a Salt and its Non-Saturated Solution.* **A. Campetti.** (Accad. Lincei, Atti, 9. pp. 27–31, July 15, 1900.)—When a crystal of say NaCl is dropped into water or its own non-saturated solution, the chlorine ions fly off more rapidly than the sodium (63 : 38); the liquid immediately surrounding the crystal becomes negatively charged and the crystal is positively charged. This accelerates the outflow of Na and retards that of Cl ions, so that presently there is a tendency towards equalisation. On the whole the liquid is negative to the crystal. The difference of potential is of the same order as that between a more and a less concentrated solution of the same salt. A. D.

2467. *Electromotive Behaviour of Substances with Several Degrees of Oxidation, I.* **R. Luther** with **D. R. Wilson.** (Zeitschr. Phys. Chem. 34. pp. 488–494, Aug. 17, 1900.)—The conclusion that the oxidation of copper to the cupric state must represent an energy-change equal to the sum of those required to oxidise it to the cuprous and then to the cupric state is verified by

measuring the E.M.F. of contact between copper and copper sulphate solution and comparing it with that of the combinations—

$$Cu \mid CuCl \text{ (solid)} \mid KCl \text{ (solution)}$$

and—

$$Pt \mid CuCl \text{ (solid)} \mid CuSO_4KCl \text{ (solution)},$$

as well as with similar combinations in which the bromides were used.

T. M. L.

2468. *Electrosynthesis of Organic Substances.* **O. Dony - Hénault.** (Zeitschr. Elektrochem. 7. pp. 57–65, Aug. 2, 1900.)—In a previous paper [Abstract No. 1715, (1900)], reactions were considered in which the discharge-potential of liberated ions was diminished by the presence of a non-electrolyte or depolariser with which the ions were capable of directly reacting. The synthesis of iodoform is now shown to belong to a different class of reactions, the discharge-potential of iodine ions in a solution containing sodium carbonate being unaltered by the addition of alcohol. The formation of iodoform, both by chemical and by electrolytic processes, is considered to be due, not to the direct action of iodine on alcohol, but to the secondary action of hypoiodous acid on alcohol. The hypoiodous acid is formed by the interaction of iodine and hydroxyl ions and partly undergoes decomposition with the production of iodic acid, partly reacts with the alcohol to form iodoform, the yield of the latter depending on the relative velocity of these two reactions. The correctness of the author's views is proved by the facts that (1) the conditions which are most favourable to the formation of iodoform by the electrolysis of a solution of sodium carbonate and potassium iodide in presence of alcohol are also those which are most favourable to the production of hypoiodous acid in the absence of alcohol; (2) the addition of excess of iodide or iodate, which hinders the decomposition of hypoiodous acid, favours the production of iodoform; (3) iodoform is readily obtained by the action of hypoiodous acid on a solution of sodium carbonate and potassium iodide in presence of alcohol, free iodine being entirely absent.

N. L.

2469. *Electrolytic Conduction without Decomposition.* **Camichel** and **Swyngedauw.** (Comptes Rendus, 131. pp. 375–377, Aug. 6, 1900.)—The authors cause currents to flow in circuits composed entirely of electrolytes, with the object of seeing if any decomposition takes place. The necessary E.M.F. in the electrolytic circuit was obtained either by induction, a transformer being made with an electrolytic secondary, or by forming a closed electrolytic circuit in sections of different solutions, each contact giving rise to an E.M.F. No decomposition was observed.

W. R. C.

2470. *Carbide of Calcium Works in Austria and Hungary.* **Gin.** (Ind. Électrochim. 4. pp. 71–76, July, 1900. Abstract of a paper read before the Paris Congress on Applied Chemistry, 1900.)—The hydraulic and electrical installations at six works are described in this paper—in some cases with great detail, in other cases only briefly. The works dealt with are situated at Meran, Paternion, Lend-Gastein, Mattrei, Jaice, and Lobkovice.

The Gin and Leleux type of carbide furnace is used at two of these works, namely, Meran and Paternion, and these are naturally the most fully described. The works at Meran have been frequently described [see Abstract No. 278, (1900)]. At Paternion a fall of 60 metres is utilised to drive three 400-H.P. turbines, each of which is direct coupled to a tri-phase generator. These generators run at 350 r.p.m. and generate current at 60 volts pressure. The

furnace house contains nine furnaces of the Gin and Leleux double type, each equal to 125 E.H.P.

At Lend-Gastein a fall of 68 metres is utilised in turbines built by Escher-Wyss & Co., of Zurich. The total power generated is equal to 4,000–5,000 H.P., but no details of these works are available for publication.

At Matrei 1,500–2,000 H.P. is utilised. The turbines were built by Ganz & Co., of Buda-Pesth, and the generators and furnaces by Siemens & Helske.

The Jaice works have a maximum of 8,000 H.P. at command ; the eight turbines, each of 1,000 H.P., being by Ganz & Co. The generators and furnaces are by Schuckert & Cie. The early operation of this plant has been unfortunate, and important changes are now being made. At Lobkovice only 800–450 H.P. is available. Intermittent furnaces are used ; and 700–900 kg. carbide per day (800 tons per annum) are being produced here. J. B. C. K.

REFERENCES.

2471. *Theory of the Voltaic Cell.* **W. R. Cooper.** (Electrician, 44. pp. 434–436, Jan. 19 ; 45. pp. 852–854, Sept. 28 ; and 896–897, Oct. 5, 1900.)—Articles on the electrolytic mechanism and the osmotic pressure theory of primary cells.

2472. *Liquid Crystals.* **O. Lehmann.** (Ann. d. Physik, 2. 4. pp. 649–705, Aug., 1900.)—Paper similar to that referred to in Abstract No. 1876 (1900).

2473. *Theory of Solutions.* **G. Jaumann.** (Akad. Wiss. Wien, Sitzb. 109. IIa. pp. 512–553, May, 1900.)—A theory of solutions based on the Faraday-Maxwell theory, and independent of Arrhenius's theory of electrolytic dissociation, except in so far as two modifications of an electrolyte are postulated, of which one (in concentrated solutions) shows a normal osmotic pressure, and the other (in dilute solutions) a pressure twice as great. T. M. L.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

2474. *Compound Steam Engine by the Prager Maschinbau A.-G. at the Paris Exhibition.* (Génie Civil, 37. pp. 181–183, July 14, 1900.)—This engine, which is to be used for lighting the station at Pilsen, has the peculiarity that the high-pressure engine has trip valves, and the low pressure cylindrical Corliss valves.

This arrangement was adopted in order to reduce to a minimum the steam consumption. Should any leakage occur with the H.P. trip valves the steam is not lost but goes to the L.P. cylinder. On the L.P., on the contrary, the clearances and chance of leakages must be reduced to a minimum, and this can be easily effected and maintained by the use of the Corliss valve.

The engine is a two-cylinder compound engine with the cranks set at 90° at either end of the crank shaft, and a Krizik dynamo in the centre. As the engine is running at Paris without condensing and at 120 revolutions, it indicates 240 H.P. The H.P. cylinder is 14·56 inches diameter, the L.P. 23·62 inches, with 27·56 inches stroke. The H.P. cylinder is surrounded by a jacket in which there is live steam; the L.P. jacket has the pressure of the receiver. The H.P. valve gear is a modified form of the Radovanovic gear. The lubrication is supplied from a main reservoir, and small cocks, situated near the parts to be lubricated, regulate the supply of the oil. The air pump, when fitted, is to be of the vertical double acting type and worked off the tail rod of the L.P. cylinder, through a bell crank lever. L. S. R.

2475. *Cylinder Proportions for Compound and Triple Expansion Engines.* **B. C. Ball.** (Engineer, 90. pp. 97–98, July 27, 1900. Paper read before the American Society of Mechanical Engineers, March, 1900.)—Opinion seems to be divided on the question as to whether there should be any terminal drop in any cylinder but the last, but no series of experiments of a conclusive nature seem to exist to determine this point. The author, after discussing the ideal diagram, cylinder ratio, &c., shows how these have to be modified in practice due to the varying conditions under which the engines may be called upon to work. The actual dimensions ultimately settled upon have in nearly all cases to be the result of a compromise. For instance, cylinder condensation modifies at once what would otherwise be the ideal dimensions and ratio of cylinders, &c. Greacen of Perth Amboy, New Jersey, made a lot of experiments by altering the initial pressure, and bushing the H.P. cylinder to alter the cylinder ratio, and the results of his experiments are given at some length, but are summed up in the following table:—

With 60 lbs. per sq. in. steam	....	Cylinder ratio 4 to 1
,, 85 ,, ,, ,,	....	,, ,, 5 to 1
,, 110 ,, ,, ,,	....	,, ,, 6 to 1
,, 135 ,, ,, ,,	....	,, ,, 7 to 1
,, 160 ,, ,, ,,	....	,, ,, 8 to 1

As a result of his investigations he gives the following as the main factors in the reduction of cylinder condensation :—

(1) Reduction to a minimum of the area under varying pressure and temperature. (2) Reduction of the range of temperature. (3) Use of steam jackets and reheaters or superheaters.

Rockwood has now built several compounds with a consumption of less than 13 lbs., and some have been as low as 12 lbs. per H.P. per hour. L. S. R.

2476. *Reheaters in Multiple-Cylinder Engines.* **R. H. Thurston.** (Mech. Engineer, 6. pp. 241–243, Aug. 18, 1900. Abstract of a paper read before the American Society of Mechanical Engineers at Cincinnati.)—Reheaters have been used since 1859, by various engine builders on both sides of the Atlantic. With the triple engine at the Massachusetts Institute of Technology, indicating 88 to 90 I.H.P., consumption of steam was 15·95 lbs. to 16·03 lbs., with no reheaters in use. With the reheaters in use, and the engine indicating 105–107 I.H.P., the consumption was 14·5 lbs. to 14·7 lbs. No jackets were used in either case. In the case of the Sibley College engine where jackets were used, no marked difference due to the use of reheaters could be detected.

Experience seems to indicate that 10 per cent. of superheat means about 20 per cent. saving in cylinder condensation. Reheaters in compound engines only affect the L.P. cylinder, and may probably reduce by one-half the cylinder condensation. The most striking successes in producing exceptional economy are exhibited by engines fitted with superheaters between the cylinders, thus securing a proper "reheat." A partial reheat in cylinders, when the ratio of expansion is small, is practically useless. The dimensions of the reheater must be proportional to the quantity of steam passing through, its degree of dryness and the quantity of superheat required, and where possible the actual moisture should be taken out of the steam before it reaches the reheater. A superheating reheater is a desirable accessory, but anything short of an actual superheat is undesirable, as this work, done by a complicated and costly apparatus, would be much better performed by an apparatus less costly in construction and maintenance. L. S. R.

AUTOMOBILISM.

2477. *Henriod Automobiles.* (Locomotion Automobile, 7. pp. 532–535, Aug. 16, 1900.)—A short biographical sketch of the work of Henriod in connection with motor vehicles is given, and a description of his latest type of 25-H.P. petrol car, with photographic and detail illustrations, showing clearly the main features of construction. The engine is placed at the extreme front of the underframe; it has four horizontal cylinders arranged in pairs, nearly opposite one another on either side of the crank case. The crank shaft lies in the direction of length of the vehicle, and drives through a friction clutch, a shaft in alignment, which runs in bearings in a gear case attached to the underframe. Upon this shaft are four fixed spur wheels, and upon a parallel shaft in the same horizontal plane is a sliding sleeve, carrying spur wheels so arranged that by shifting the position of the sleeve each may be caused to engage with the corresponding wheel keyed on the first shaft. Four forward speeds may thus be given to the vehicle, and a reverse motion may be obtained by engaging a third pinion between the pair of wheels which give the slowest forward speed, when these are out of engagement.

By means of a bevel gear the power is transmitted from the second motion shaft to a cross countershaft upon which is the differential gear. The road wheels are driven independently from this shaft by means of sprocket wheels and pitch chains.

Steering is controlled by a hand wheel which operates the pivoted axles of the front wheels through a worm gear and suitable links. Three band brakes are provided. The general design conforms to the accepted practice for high-speed carriages; the centre of gravity of the mechanism is low, and the engine well balanced. C. R. D'E.

2478. *Chaboche Steam Car.* (Locomotion Automobile, 7. pp. 594–596, Sept. 13, 1900.)—The author describes a steam delivery van for loads up to about 1 ton. The boiler is placed at the extreme front of the underframe and supplies steam to a pair of single cylinder horizontal engines placed on either side exterior to the frame members. The crank shafts are coupled, and the power is transmitted through a clutch and single reduction chain gear to the exterior of the differential which is mounted at the centre of the live rear axle. The special feature is the boiler, which is of the flash type, consisting of numerous coils of steel tubing arranged so that the connections are not exposed to the full heat of the furnace, and adapted to withstand very high pressures. Instead of the feed water being pumped direct through the coils, it is supplied under pressure of air at 200 to 400 lbs. per square inch, from a cylindrical vessel placed by the side of the driver. The air pressure is maintained by a pump driven by gear from one of the engines, and is controlled by a stop-cock within reach of the driver, as is also the feed of water to the boiler. The advantages claimed are that after a stop has been made the car may be started immediately instead of having to pump in water by hand as in other flash boilers; that when the car is stopped there is no pressure left in the boiler; and that the air pump has only to be worked intermittently to keep up the pressure above the feed water. The boiler is fired from the top; to facilitate stoking the fuel is done up in paper bags, each containing about 10 lbs. Particulars of cost of running, &c., supplied by the maker, accompany the article; also a photograph and a plan drawing of the vehicle. C. R. D'E.

2479. *Superheated Water Motor.* (Scientific American, 83. pp. 116–117, Aug. 25, 1900.)—A description of the system now being tried on the New York and Putnam Railway. Three carefully insulated storage tanks, having a total capacity of 700 gallons, are carried beneath the car, and are charged with water at a pressure of 700 lbs. per square inch at a temperature of 500°. Instead of taking steam directly from this, whereby the temperature of the whole would be rapidly diminished, a definite quantity of water is drawn off at each stroke from the bottom of the reservoir into a water-chamber at the end of the engine cylinder, and is thus not allowed to begin to evaporate until after it has finally left the reservoir. From this chamber a portion of the water is given off as steam, which is admitted to the cylinder in the usual way, the surplus water being drained off. Small compound engines are used, one pair on each truck, and drive the wheel axles through a pair of spur-wheels. It is expected that with tanks fully charged the car will be capable of running for forty miles at a speed of from thirty to forty miles per hour. [No details are given regarding efficiency.] H. R. C.

2480. *Road Locomotion.* **H. S. Hele-Shaw.** (Inst. Mech. Engin., Proc. 2. pp. 185–245 ; Discussion, pp. 246–253, April and June, 1900.)—This paper opens with a general statement of the circumstances which led up to the passing of "Locomotives on Highways Act of 1896, and consideration of the advantages consequent on the use of mechanically propelled vehicles for the distribution of goods in cases where the terminal charges make the cost of transport by rail prohibitive. Curves of cost of conveyance and terminal charges are given, which "show clearly that up to forty miles there is a field for a system of conveyance in the working of which terminals are not incurred." The "problem of the wheel rolling upon a road" is then considered, diagram illustrations being given of six types of wheels for heavy lorries of English construction ; also graphical records, taken with Brown's viagraph, of the vibrations due to various road surfaces. The performance in practice of the several forms of wheel tyres is considered, and conclusions drawn therefrom, illustrations being given of four types of pneumatic tyre, and also of the "relative displacement caused by iron and pneumatic tyres at high speeds." "Steering and turning" forms the subject of the second part of the paper. With regard to the steering of motor vehicles, the author states that the great majority of these "are steered upon the principle invented by Ackermann as long ago as 1818." Diagram-illustrations are given showing the steering systems employed in the vehicles of Daimler, Clarkson and Capel, and others, and the Davis steering gear, the problem of obtaining differential movement of the steering wheels when describing curves being considered with reference to this latter diagram. "Turning," and the necessity of employing a "differential gearing, or jack in the box," are briefly considered. The third section of the paper deals with "Motive Power and Transmission," under which head the general considerations which govern the use of internal combustion engines, steam engines, and electric motors are dealt with. With regard to internal combustion engines, considerations are discussed in connection with carburettors, ignition, cooling, starting, governors, and balancing, diagrams of eight methods of balancing being given. Under the head of "External Combustion (Steam)" motors, diagrams are given illustrating the general distribution of the main parts of six English-built lorries. Several forms of liquid fuel-burners are then described and illustrated. The regulator employed in connection with the furnace of the Stanley boiler is referred to as a "burner" for the use of light petroleum spirit.

Steam generators are then dealt with, various types of water-tube and Flash boilers being illustrated and briefly described.

Electricity and transmission and gearing are considered, and finally the cost of transport by motor waggons, tables being given of the results of trials made at Liverpool.

Appendices are added which state the working cost of motor waggons in practice in four individual cases, and in a final appendix the results of the Automobile Club trials of 1899 are summarised by Bryan Donkin.

Discussion.—**J. A. F. Aspinall** stated that he had given one of Thornycroft's vehicles a trial in Liverpool and Manchester, and had found the results "fairly satisfactory for some kinds of work, but it could not be said that the vehicle was any cheaper than horse traction for all work." **J. Brown** described his "viagraph" and discussed its uses in the determination of the extra power required to draw a vehicle over rough roads. **Hele-Shaw** in replying said that the owner of a car in the 1,000-miles' trial then proceeding, stated that in estimating expenses he considered it about ½d. per

mile for petroleum spirit, and about 2d. per mile for wear of pneumatic tyres.

[The discussion is continued in the following Abstract.] C. R. D'E.

2481. *Recent* 1,000-*miles' Road Trials*. **H. S. Hele-Shaw.** (Inst. Mech. Engin., Proc. 2. pp. 254–265 ; Discussion, pp. 266–321, April and June, 1900.) —This paper is supplementary to that dealt with in the preceding Abstract. It gives a short general account of the 1,000-miles' trial organised by the Automobile Club of Great Britain and Ireland, and is accompanied by a map of the route and tables giving particulars of the performance of the vehicles on the several hills included in the trial, and of the general running of the cars throughout. The author is of opinion that the general freedom from failure of many of the vehicles was due to the use of pneumatic tyres, and that the most important lesson of the trial was the absolute necessity for constant care and attention in order to obtain satisfactory running.

Discussion.—**Bryan Donkin** compared by means of curves the total running weight, and the cost of fuel per ton mile, as shown by the trials at Richmond in 1899, and at Birmingham in 1898. These curves show that "the cost of fuel is very much greater with the lighter and higher speed vehicles, and very much less with the heavier and slower vehicles." **H. Sturmey** mentioned that C. S. Rolls, who drove the largest and fastest pleasure cars in this country, had calculated the cost of pneumatic tyres at about 2d. per mile, and referred to the necessity for improvement in transmission gears rather than in the motors themselves. He said that three or four years ago he carried 15 gallons of cooling water on his petrol car, now only 4 gallons are carried owing to improvements in methods of cooling. **W. Worby Beaumont** spoke of the necessity for better roads, and criticised the author's remarks on the heating of carburettors for vaporising petroleum spirit, stating that the larger proportion of such carburettors required no heating at all. With regard to governors, engines were frequently run for part of the time at a normal speed of, say 750 r.p.m., but this could be accelerated to 1,500 or 1,600 r.p.m. by preventing the action of the governor. He also remarked on the inefficiency of certain methods of cooling the cylinders of petrol motors, and that the vibration in some motor cars was the result of infrequent ignition rather than of want of perfect balance of the moving parts. C. E. D'E.

GENERAL ELECTRICAL ENGINEERING.

2482. *Pasting Battery Plates.* **F. Peters.** (Centralblatt f. Accumulatoren u. Elementenk. 1. pp. 227–228, July 1; and 259–262, Aug. 1, 1900.)—Three methods of pasting plates for accumulators were tried—(*a*) That of S. Farbaky and S. Schenek (German Patent No. 37012), in which the material is mixed with 25 per cent. sulphuric acid; the mass when nearly dry is pressed into the grid, and is allowed to dry in the air for two to three days. It is next quickly dipped in 25 per cent. acid, drained, and after twenty-four hours again dipped in the acid, but this time sufficiently long to allow effervescence to take place. After standing a further twenty-four hours the plate is dipped for a third time for ten to twelve hours. (*b*) The process of J. Zacharias (Die Accumulatoren, Jena, 1892, p. 89), in which water only is mixed with the lead oxide, &c., and the paste pressed in the grids or formed into small rods. The plates are then dried and are ready for use. (*c*) That of W. L. Silvey (American Patent No. 459535), who mixes the oxide with water and applies the stiff paste to the plates, which, whilst the paste is still moist, are dipped into sulphuric acid of density 1·1–1·2, where they remain, according to the thickness of the plate, for two to three days. The process is then complete, and they may, if necessary, be so far dried that they can be handled without damage. Cells were built up with these three types of plates, and tested by discharging at various rates. Observations were also made with the use of a supplementary cadmium electrode. [See Abstracts Nos. 1068 and 1416 (1899)]. The following table is given :—

Rate of Discharge Amperes.	Watt-hour Capacity.		
	Farbaky-Schenek.	Zacharias.	Silvey.
4·2	34·27	25·59	26·27
6·0	28·52	22·68	22·80
8·4	26·33	18·46	18·51
10·0	21·63	18·51	18·75
14·0	21·14	19·32	19·31

W. W. H. G.

2483. *Battery Plates for Traction.* **J. K. Pumpelly.** (Elektrochem. Zeitschr. 7. pp. 83–86, July, 1900.)—Three photographs are given of accumulator plates that had been used about two months in an electric car. The type of plate which had most suffered was of the Planté type. It had been produced electrochemically in a solution of sulphuric and nitric acids. Mechanically it represented a new process, and was carefully manufactured. This compared very unfavourably with a Faure plate from the same car, and which had done the same amount of work. W. W. H. G.

2484. *Burning of Accumulator Plates.* **O. Schmidt.** (Centralblatt f. Accumulatoren u. Elementenk. 1. pp. 216–218, June 15, 1900.)—The author advocates the use of oxygen and hydrogen produced by electrolysis. The method presents so many advantages that it has been adopted in most of the

works in which Tudor accumulators are manufactured. The gases are produced in a filter-press type of decomposition apparatus, in which the separate chambers are in series so that the apparatus may be directly connected with the main electric leads. The construction of the apparatus (of which no details are given) prevents the admixture of the gases. The gases are especially pure, the hydrogen being 99 per cent., and the oxygen 97 per cent. From the decomposition apparatus the gases may be led directly to the blowpipe. If small gasometers be used the required small differences of pressure may be maintained. The apparatus may be continually worked with but little attention. The blowpipe requires each hour 100 litres of hydrogen and 33 litres of oxygen. W. W. H. G.

2485. *Dry Accumulators.* **C. Liebenow.** (Centralblatt f. Accumulatoren u. Elementenk. 1. pp. 67–70, Feb. 15, 1900.)—In Germany a number of patents exist for storage cells in which the electrolyte is held by absorbent materials [see Zierfuss D.R.P. No. 95269, Behrend No. 103044, Chemische Fabrik Winkel No. 109016]. Among the materials used have been glass, wool, porous siliceous earth (*Kieselguhr*), albumen, starch-paste, baked clay, pumice-stone, cellulose, soap, fatty acids, gypsum, sand, asbestos, and patent gelatine. The disadvantages arising from the use of these materials is pointed out, and the many troubles that are likely to arise are enumerated. Hitherto experiments in this direction cannot be regarded as very successful. W. W. H. G.

2486. *Controllers for Continuous Current Electric Lifting Gear.* **M. Vogelsang.** (Elektrotechn. Zeitschr. 21. pp. 635–640, Aug. 2, 1900.)—In this paper the author first deduces equations for the distance x through which the load Q will move after the current has been cut off. In the case where the load is being raised—

$$x = \frac{\eta \cdot \frac{m_2 v^2}{2} + \frac{m_1 c^2}{2}}{Q + \eta B}$$

where η is the efficiency of the gearing when kinetic energy is being converted into potential energy, m_1 the mass of the load, m_2 the reduced mass of the armature and v the velocity thereof, c the velocity of the load, and B the braking force. For the case, where the load is falling—

$$x = \frac{\frac{m_2 v^2}{2} + \eta' \frac{m_1 c^2}{2}}{B - \eta' Q}$$

where η' is the efficiency of the gearing when potential energy is being converted into kinetic energy. In practice η lies between 0·5 and 1 and η' is positive, B must therefore be at least equal to $\eta' Q$ in order to be effective.

The system of control employed by the author consists in short-circuiting the motor through more or less resistance, so as to regulate the braking force, and thus the velocity at which the load descends. A mechanical brake is thus only required for bringing the load to a standstill. This brake can be kept normally in the "on" position by means of a spring or weight, and be released by an electromagnet, which is wound for connection in parallel with the motor, and is itself provided with a high-resistance shunt to receive the induction current when the circuit is broken. This shunt is preferably permanently connected across the terminals of the electromagnet; it may, however, only be thrown into circuit, when required, by means of the con-

troller. The controller whereby the above-mentioned connections are made consists of a vertical shaft bearing insulated segmental contact-pieces engaging with spring contact-fingers, spaces being arranged between adjacent fingers, and into these spaces extend the pole-pieces of electromagnets, so as to prevent arcing. Diagrams are given showing various schemes of connections, together with photographs of several forms of controller, and a section of one of them. C. K. F.

2487. *Insulation by Freezing.* (Elect. World and Engineer, 36. p. 287, Aug. 25, 1900.)—The dielectric strength of ice increases with a falling temperature, and is more particularly effective against intermittent currents or those alternating at high rates. Tesla suggests inserting a transformer in a freezing jar, and has patented a system of underground conductors where the two mains are the flow and return pipes which carry a cooling material, the pipes themselves being buried in wet cement or water, &c., in a trough.
M. O'G.

2488. *Power Transmission by Shafting* versus *Electricity.* (Eng. News, 44, pp. 18–21, July 12, 1900. Abstract of a report presented by a Committee at the Convention of the American Railway Master Mechanics' Association.)—The average efficiency from engine to tools for steam engine transmission is 50 per cent.; from motor to tools it is 52 per cent. where the machines are grouped on shafting, or 60 per cent. where each tool has its own motor. Where electricity is substituted for steam, the attendance bill will be practically unaffected in a large shop, as also will be the repairs bill. The capital cost of electric equipment will be approximately double that of steam equipment, but the former has enormous advantages, because it permits labour-saving devices, cranes, &c. In ordinary steam-equipped factories the tools have generally to be installed with a view to convenient application of power; with electric equipment, the tools are placed where the work can be handled with most advantage. Increased output is the chief advantage in motors.

A valuable table is given showing the power required for various machine tools. With electric plant, the efficiencies at full load are: Generators 86 to 90 per cent., transmission lines 90 to 95 per cent., motors 78 to 90 per cent.; overall 62 to 77 per cent. At partial load the machine efficiencies drop, but the line efficiency rises so that the overall efficiency is practically independent of the load. In an average size railway shop plant, the all-day efficiency from engine to motor pulley may be taken as 65 per cent. As a rough guide in planning shop power plants, it may be noted that each man in a railway shop will require roughly 0·4 H.P.

The disadvantage of the alternating current motor for general shop work is its high and not easily-varied speed. For shafting this is quite satisfactory. The induction type alone is applicable for shop uses.

For generators of 75 H.P. or less, belt-driving answers all practical purposes, but above this size direct-coupled sets are more economical. The generator load in a shop seldom exceeds 50 per cent. of the combined motor capacities, and the effect on the generator of running travelling cranes, turntables, &c., need not be considered. For individual tool-driving the compound-wound variable-speed motor is recommended as a substitute for the usual shunt-wound motor. One of the chief advantages of electric driving is the possibility of simple speed regulation for large tools. For travelling cranes, hoists, transfer tables, turn-tables, and boiler-shop plate rolls, which start under load, run at variable speed, stop and reverse, the series-wound

motor is the best. In general, where tools require less than 3 H.P. each, it is best to group them on short line shafts in groups not exceeding 25-H.P. Where more than 3 H.P. is required or where variable speed or intermittent running is desirable, each tool should have its own motor. The conclusions arrived at are that (i) in a small shop consisting of one building equipped with small tools for light work, electric driving is not a paying investment, but electric lighting is economical, and the lighting dynamo may be utilised to run a few labour-saving electric tools, such as cylinder borers, turn-tables, &c.; (ii) in an extensive railway shop plant, a central power station and electric transmission are always advisable, as they result not only in the most economical system of operation but make possible more important shop economics, viz., an increase in quantity and quality of output and a reduction in cost of handling the same.

In an appendix, examples of shop power plants are given, including descriptions of those at the Westinghouse Air-Brake Company's works and the Baldwin Locomotive Works. The former company replaced 23 scattered Westinghouse steam engines of 5 to 200 H.P., driving line shafting, by three 400-H.P. Parson's steam turbines in a power house close to the boilers. The turbines are direct-coupled to three-phase alternators, running at 3,600 r.p.m., which supply 56 induction motors having an aggregate capacity of 1,050 H.P. The original shaft sections were about 400 feet long, and belted to their engines in the centre. These sections have now been cut into four parts, and a 15-H.P. motor belted to each 100 feet. Thorough comparative tests were made with the old steam and new electric driving, and the results show a saving for the latter, during a day's run of 11½ hours, of 33 per cent. of fuel consumed and 40 per cent. of water evaporated. E. H. C.-H.

REFERENCES.

2489. *Alternate Current Meters.* **H. Armagnat.** (Écl. Électr. 24. pp. 92–97, July 21, 1900.)—An article, illustrated by patent drawings, describing the Hookham, Thomson-Houston, Davis and Conrad, and the Siemens meters.

2490. *Electrical Coal Cutters.* **S. F. Walker.** (Eng. Mag. 19. pp. 712–727, Aug. 1900.)—An illustrated article descriptive of various types of electrical coal cutters.

2491. *Heating of Underground Cables.* **K. Wilkens.** (Elektrotechn. Zeitschr. 21. pp. 691–692, Aug. 9, 1900.)—The author here criticises a paper on the same subject by Apt. [Elektrotechn. Zeitschr. 26. July, 1900, and Abstract No. 1925 (1900)], and attacks the assumptions made in the theoretical portion of the paper dealing with the conduction of heat from the cable. J. B. H.

2492. *Design of Tractive Electromagnets.* **W. E. Goldsborough.** (Elect. World and Engineer, 36. pp. 125–132, July 28, 1900.)

GENERATORS, MOTORS, AND TRANSFORMERS.

2493. *Determining Moments of Inertia of the Rotors of Dynamos.* **A. Hay.** (Elect. Rev. 47. pp. 287–288, Aug. 24, and 327–330, Aug. 31, 1900.)—A clear description is given of five methods of experimentally determining the moments of inertia of the rotors of dynamos. In problems connected with the parallel running of alternators and in analysing the various losses which take place in a generator a knowledge of these moments of inertia is essential. The first method described is the ordinary laboratory method of determining moments of inertia by means of torsional vibrations. The rotor is suspended by a steel wire rope, and the time of a complete oscillation (T_1) is observed. Its moment of inertia is next increased by distributing weights symmetrically round the axis. Let T_2 be the new period and let I be the moment of inertia of the rotor, and I_w the added moment of inertia, then—

$$I = I_w \frac{T_1^2}{T_2^2 - T_1^2}.$$

Results of experiments are given showing that this is an accurate method in practice.

In the second method the machine is run up to any desired speed, and then the power being cut off, the angular velocities (ω) of the rotor are noted at subseqent intervals. From these readings a curve is plotted. From this curve the rate of decrease of the angular velocity ($d\omega/dt$) for any particular value of ω can be found by drawing a tangent to the curve in the ordinary way. If the value of the retarding torque be T, then $T = -I\, d\omega/dt$. If we now mount a disc flywheel on the rotor shaft and obtain a new retardation curve, then—

$$I = I' \frac{d\omega_2/dt}{d\omega_1/dt - d\omega_2/dt},$$

where I' is the moment of inertia of the disc flywheel, and $d\omega_1/dt$ and $d\omega_2/dt$ denote the angular accelerations corresponding to the same value of ω in the two cases.

In the third method the machine is run as a separately-excited motor, and the torque is calculated from the watts (W) given to the armature. Hence we can find I from the equation—

$$I\omega d\omega/dt = -10^7(W - C^2R)$$

where C^2R is the power expended in heating the armature. The readings on a Weston voltmeter connected across the brushes were used to find the speed as the rotor slowed down. It was found that the friction varied very irregularly for the first half-hour or so. In order to get satisfactory readings the rotor had to be kept running for two or three hours. In the fourth method two retardation curves were obtained, one being the normal curve and the other corresponding to a larger resisting torque caused by putting a suitable resistance across the machine terminals. The additional torque (T_0) is calculated from the current, the resistance of the circuit, and the angular velocity. Then—

$$I = \frac{T_0}{d\omega_1/dt - d\omega_2/dt}.$$

The fifth method only differs from the fourth in increasing the torque mechanically instead of electrically. An accurate method of getting the

retardation curve is by a smoked recording drum similar to those used in physiological laboratories. Diagrams made by one of those instruments are shown. A. R.

2494. *Locating Short-circuits in Armatures.* (Street Rly. Journ. 16. pp. 583–585, Aug., 1900.)—The North Jersey Street Railway Company locate short-circuits in their armatures by the alternating-current method. The armature is mounted on the winding bench or lathe, and a portable testing-stand brought up to it. This stand consists of a framework of angle-iron mounted on rollers and carrying a magnetising spool on a curved pole-piece shaped to fit against the outside of the armature. The magnet core is made of laminated iron about $\frac{1}{32}$ in. thick, and its shaped face is about 11 inches long by 11 inches high. The magnetising coil is wound with 1,210 turns of No. 63 B. & S. wire on a spool $11\frac{3}{8}$ in. × $3\frac{3}{8}$ in. × $3\frac{3}{16}$ in. The curved face of the polepiece is adjusted to the face of the armature by a hand-wheel and screw. The armature is rotated by hand in this alternating field, and a thin strip of iron is passed around the armature. When this strip comes over the tooth lying between two short-circuited coils it will vibrate in unison with the alternating current supplied to the magnet. This vibration is due to the fact that the magnetism produced by the local flow of induced current in the short-circuited coils is not synchronous with the magnetism in the adjacent teeth. When placed at any winding bench an armature can be tested by this method in less than one minute. E. H. C.-H.

2495. *Parallel Operation of Direct-connected Alternators.* **H. G. Stott.** (Elect. World and Engineer, 35. pp. 240–241 and 255–256, Feb. 17, 1900.)—Owing to armature reaction it is necessary that the voltage of the incoming alternator should be somewhat greater than the voltage at the bus-bars. The armature reaction is specially marked at low-field excitation. The running machine has already had its field adjusted to compensate for its armature reaction, and when the incoming machine is thrown in parallel with it a slight difference of phase is sufficient to allow the running machine to send an almost wattless current into it, tending to demagnetise its fields and finally drive it as a motor. W. G. R.

2496. *Single-phase Induction Motors.* **C. P. Steinmetz.** (Amer. Inst. Elect. Engin., Trans. 17. pp. 37–73, Jan. ; Discussion, pp. 170–180, March, 1900.)—The principal feature of this paper is a description of the use of a condenser connected to a tertiary circuit in a single-phase motor. The tertiary coil is wound at right angles to the stator winding, so that the mutual induction between the two is approximately zero. The E.M.F. developed in the tertiary winding is therefore due to its mutual induction with the rotor coils. The result is that an E.M.F. is induced in the tertiary coil which is suitable for a condenser connected in series with it. If this condenser has the same admittance as the rotor exciting admittance the tertiary circuit gives the secondary magnetising current, that is, the secondary current becomes zero at synchronism, just as in a polyphase motor, and the primary current is reduced to the magnetising current of the main magnetic flux only. If twice this capacity is used the condenser current in the tertiary circuit supplies the magnetisation of the quadrature magnetic flux, and at the same time causes a current in the secondary to flow which gives the primary magnetisation also, and the primary circuit carries energy current only, that is, the total magnetisation is given by the condenser in the tertiary circuit, or the motor has 100 per cent. power factor. W. G. R.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

2497. *Regulation in Long-distance Transmission.* **C. L. Cory.** (Journal of Electricity, S. F. 10. pp. 6–9; Discussion, pp. 9–13, July, 1900. Paper read before the Tamalpais Meeting of the Transmission Association, June, 1900.)—The author considers the question of regulation in the case of the transmission line now being installed by the Standard Electric Company of California. This line, 150 miles in length, is to transmit 10,000 kw. from the Mokelumne River to San Francisco, at a pressure of 60,000 volts. The system is three-phase and the line consists of three aluminium stranded wires, ¾ inch in diameter, having cross sections of 471,034 circular mils. The resistance per mile of the wire is 0·205 ohm at 70° F. The distance between the conductors is 42 inches. The frequency to be adopted is 60. The author makes his calculations for a single-phase transmission delivering 3,000 kw. The inductance of the line is 0·48 henry. The impedance at 60 ∿ is 200 ohms, at 30 ∿ 113 ohms. The capacity of the line (neglecting the influence of the earth) is 1·43 m.f., and the charging current due to this at 60,000 volts is 32·25 amperes at 60 ∿ . The apparent energy required to charge the open line is 3,348 kw., and the real energy 32 kw. Assuming the capacity to be distributed, one-sixth at each end and two-thirds in the middle, a voltage of 47,676 volts at the generator would produce 50,000 volts at the distant end, on an open line. Taking a full-load current of 60 amperes with a power factor of unity to deliver 60 amperes at 50,000 volts, there must be supplied by the generator 67 amperes at 58,800 volts; the watt loss is 10 per cent. With a power factor $=0·8$, the inductive current is 45 amperes, and the charging current 32 amperes, and these tend to neutralise each other; the current required at the distant end to give 3,000 kw. at 50,000 volts is 75 amperes, and the generator must supply 62·1 amperes at 60,000 volts.

The author concludes by pointing out that the best way to reduce the charging current is to produce a neutralising inductive current by the use of induction motors at various points throughout the length of the line; induction motors are preferable in this respect to artificial impedance coils.

Discussion.—**Lighthipe** stated that in Southern California three-phase plant at 33,000 volts, the capacity of the line was considerably diminished by earthing the centre of the star at each end of the line. **Cory** (in reply to various questions) stated that the capacity of the line varied materially with the atmospheric conditions. Synchronous motors had the opposite effect to induction motors unless they were run with weak fields, which was not their best working condition. G. H. B.

2498. *Regulation in Long-distance Transmission.* **F. A. C. Perrine.** (Elect. Rev. N.Y. 37. pp. 152–153, Aug. 15, 1900. Paper read before the Pacific Coast Electric Transmission Association, June 19, 1900.)—The author treats of electric transmission of power, obtained from high heads of water, for long distances at high pressure. For the regulation he makes the following recommendations:—Water-wheels should be subdivided into sets of small units driving one generator, and their regulation effected by deflecting nozzles; the objections to regulation by varying the flow of water is that

with high velocities of the water, this causes a variation in the level of the water in the forebay, and so affects the other wheels. Small units are advisable to save water by shutting down one or more as the load decreases. Generators and transformers should be designed, not for good non-inductive, but for good inductive, load regulation. Lines should be designed for the smallest possible capacity-current without reference to any attempt at balancing the line capacity against the load lag; such balancing is useless because the capacity current remains practically constant, while the inductive drop varies with the load. At the substations, reactance coils should be used to regulate the voltage instead of regulator transformers; reactance coils neutralise the capacity current and diminish the generator current and line loss at no load. G. H. B.

2499. *Copper Saving in the Joint Transmission of Direct and Alternating Currents.* **F. Bedell.** (Elect. World and Engineer, 35. pp. 984–985, June 30, 1900. Abstract of paper read before the American Association for the Advancement of Science. Also Elect. Rev. 47. pp. 32–34, July 6, 1900.)—The author points out that if two direct currents or two alternating currents of the same phase and frequency, i_1 and i_2, are transmitted along the same conductor the joint heating effect is given by $R(i_1 + i_2)^2$, where R is the ohmic resistance of the conductor. If, however, a direct current i_1 and an alternating current i_2 are simultaneously transmitted along the same conductor the heating effect is only $Ri_1^2 + Ri_2^2$ since they behave independently. Thus the loss with a direct current and an alternating current superimposed is less than two direct currents of the same virtual values by the quantity $2Ri_1 i_2$. W. G. R.

2500. *Electric Transmission of Power in Factories.* **W. S. Aldrich.** (Mech. Eng. 5. pp. 822–825, June 9, and pp. 849–851, June 16, 1900. Paper read before the American Society of Mechanical Engineers, May, 1900.)—For all manufacturing operations (except the very lightest) requiring rotary motion, electric motors provide the readiest facilities. For certain very definite reciprocating movements with fixed time or distance limits, hydraulic mechanisms are best suited, though electrically driven hydraulic mechanisms with hydraulic control have proved admirably adapted to this class of work. For reciprocating movements requiring a cushioning effect, compressed air is best adapted. But for efficient service in any case compressed air requires to be reheated and used expansively in a cylinder with all parts and mechanisms practically the same as in the steam engine. An important advantage of electric driving is the comparatively high efficiency at part load. The best performance of the electric system of transmission by shafting and belts is at full load. The best performance of the electric system may be maintained from three-quarter load to 25 per cent. overload.

In the second article the author remarks that the induction motor is the most perfect motor yet developed for electric transmission in factories. It can be started from any point at almost any load and speed within its predetermined ranges. It requires no direct current for excitation, no brushes, commutator or collector rings. Its speed, however, falls off slightly as the load increases and the ability to start an induction motor from rest under a heavy load, as well as the possibility of speed changes during its operation, are obtained at some sacrifice of efficiency. It can be run at higher lineal speeds (7,000 feet per minute) than any other type. With suitable arrangements of field windings, its speed can readily be altered

in regular steps corresponding to the steps of change-wheels. If overloaded the induction motor does not readily burn out but tends to stop until the load is lightened. On account of power factors, a larger generating plant is required for an installation of induction motors than for one of direct-current motors. Synchronous motors are best where absolute uniformity of speed is required. Their power factor can be almost anything from zero to unity according to the amount of the direct-current excitation. In the revolving field type, synchronous motors are self-starting from rest at light loads, and can be designed to carry at least three times their full normal load without falling out of step, but will then be inefficient at ordinary loads. Synchronous motors have higher efficiencies than induction motors and both are generally superior in this respect to direct-current motors. The ideal conditions in a factory installation would be secured where both induction and synchronous motors were used, the former for small machines and direct driving, the latter for operating a set or group of machines. The synchronous motors would be started up just before beginning the work of the day, would have at all times a light constant load, and might easily be so regulated as to produce an almost balanced system in combination with the induction motors. In such a system of transmission, the lagging currents of the induction motors would be offset by the leading currents of the synchronous motors, if the latter were operated to produce such leading currents.

E. H. C.-H.

2501. *On Earthing Certain Portions of Distributing Systems.* **C. H. Wordingham.** (Elect. Engin. 26. pp. 93–95; Discussion, pp. 95–96, July 20, 1900. Paper read before the Municipal Electrical Association.)—If all parts of a two-wire 10,000-volt system be equally well insulated, then each wire will only differ by 5,000 volts from the potential of the earth. If, however, one conductor's insulation diminishes, the potential of the other conductor with regard to earth will at once increase. Ferranti first pointed out that, as either conductor may therefore have to withstand the full pressure it would be better to insulate one of them for the maximum pressure and ensure that it alone shall be subjected to this pressure by connecting the other conductor to earth. This simple device at once diminished the risk of breakdown, cheapened the cost of insulation, and admitted greater security to life by enclosing the insulated conductor within the uninsulated one, thus rendering it physically impossible to handle a conductor at a dangerously high potential. It is important that one point only of the zero potential conductor should be connected to earth because there is necessarily a fall of potential down its length, and, if two distant points are earthed, current will tend to pass from one to the other through the earth, and these return paths may be at almost incredible distances from the main conductor.

In the case of low-pressure distribution, the object of earthing one conductor is not to diminish the cost of insulation because there is no appreciable difference in the cost for 200 volts and 400 volts; nor is it to secure safety to life: the chief object is to enable a consumer to be supplied at such a pressure that no one of the conductors brought into his house will exceed the limit of pressure defined by the Board of Trade to be low pressure. For keeping down the drop on the earth return of tramways, the author considers it best to feed the line from a number of independent points, either by separate generating stations or preferably by a number of transforming substations.

In a three-wire system the advantages of earthing the middle wire are chiefly those referred to above. The disadvantages are :—(i) If a leak exists

on one conductor, current is continually forced through it, thus often causing complete destruction of the insulating material : (ii) A leak on one conductor produces a short-circuit on one side of the system unless the earth connection is removable at will. In Manchester the Board of Trade requires the negative conductor of the three-wire system to be maintained at or near earth potential. In the author's opinion this undoubtedly has very severe results on the negative main with continuous currents and probably with alternating also. This effect is due to electric osmosis, whereby moisture tends to travel away from the positive pole towards the negative pole. The author finds that this occurs not only at the surface of the insulation at points of connection, but, with certain makes of rubber, at any points in the length of the cable, the rubber being evidently porous ; and though the leakage current is small at first, it suffices to cause water to enter through the pores of the rubber, thereby increasing the conductivity of the leak and eventually destroying the whole of the rubber on the negative conductors. Large blisters form within the rubber and become filled with strongly alkaline liquid, which is often under considerable pressure from the distended rubber, this pressure gradually increasing till it bursts the rubber and makes a hole completely through the insulating material. It is clear that the water cannot simply flow into the originally minute pores : it is driven in by osmosis. What happens with rubber may happen with other materials.

The author considers that the only method of effectually balancing a three-wire system is to carry the balancing back to every consumer except the smallest, and he considers that the advantage of being able to do this outweighs the disadvantages of earthing the middle wire. The utmost care, however, must then be taken to protect the mains from moisture and the only possible systems of laying mains are the "solid" system and the air-insulated systems with accessible porcelain insulators. The earth connection should be removable, continuity of supply being the first consideration ; it then becomes essential that the conductors should be earthed at one point only, which makes the use of an uninsulated return in a consumer's installation impossible. With such an uninsulated system, local earth currents between neighbouring installations would be unavoidable.

Discussion (pp. 95–96).—**A. P. Trotter** suggested inserting a resistance of 1 ohm in the earth connection to prevent a dead short-circuit. The advisability of keeping the lead sheathing 2 or 4 volts negative to the middle bus-bar is worth consideration. **R. Chamen** found it advisable to earth the middle wire through a resistance, owing to the importance of not overheating a concentric cable by a short-circuit. He ascertains the existence or absence of earths on the system by interposing an E.M.F. between the earth wire and its return, and noting the alteration in the earth current.

E. H. C.-H.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

2502. *Rathmines Electricity Works.* (Electrician, 45. pp. 631–632, Aug. 17, 1900.)—*System :* Continuous-current, three-wire, with 200 volts on each circuit, and batteries.

The *boiler-house* contains three Lancashire boilers by Taylor & Sons, each 30 feet by 8 feet, and capable of developing 7,000 lbs. of steam per hour at 160 lbs. per square inch. They are fitted with Vicars' stokers. The *feed-water* is heated by a 96-tube Green economiser, and is supplied either by an injector, or a steam-driven pump, or a pump driven by a Lundell

motor. A 6-H.P. Crompton motor drives the stokers and the economiser scrapers.

The *engine-room* contains one three-crank triple-expansion engine indicating 575 H.P. at 320 r.p.m., with cylinders 720 mm., 480 mm.; and 320 mm., and stroke 260 mm., and one two-crank compound engine indicating 240 H.P. at 360 r.p.m., with cylinders 600 mm. and 360 mm., and 200 mm. stroke. Each engine has a combination bed-plate, taking for the larger one, two 150-kw. 220-volt dynamos, and for the smaller, two 75-kw. dynamos, by Mather and Platt. A 30-inch jet condenser, by the Wheeler Condenser and Engineering Company, is employed, working with the same firm's horizontal wet and dry vacuum pumps, and a cooling tower 60 feet high.

The battery consists of 274 Tudor cells, of which 50 on each side are for regulating. Their capacity is 800 ampere-hours for 10 hours or 650 for 3½ hours, and their maximum discharge is 216 amperes.

The mains are triple-concentric, lead-covered, laid in cast-iron troughs filled with bitumen. The network is fed at seven points by 0·4 square inch and 0·3 square inch feeders, each with a pilot wire. The distributing network consists of 0·1 square inch and 0·05 square inch cables, of which about 16 miles are laid.

For street lighting 108 10-ampere Crompton arcs are run in twelve circuits of nine each, each arc having a turn-over switch and automatic cut-out with substitutional resistance; there are also 550 16-c.p. incandescent lamps on poles carrying two lamps each. G. H. B.

2503. *Stockport Electricity Works.* (Elect. Rev. 47. pp. 263–265, Aug. 17, 1900.)—*System:* Continuous-current, three-wire, with batteries; 230 volts on each circuit.

The *boiler-house* contains two Lancashire boilers 28 feet by 8 feet, by Tetlow Brothers, fitted with Wilton furnaces for burning coke breeze, the refuse of the gasworks; three cast-iron tubes, acting as fire-bars, are fitted with steam jets, which force an air-blast into the fuel through numerous small holes in the tubes. The boiler pressure is 200 lbs. per square inch. The feed-water is heated by a Berryman heater and is fed by two Worthington pumps.

The *engine-room* contains five Willans two-crank triple expansion engines, three of 56 kw. and two of 140 kw. Each drives directly a two-pole McClure and Whitfield dynamo. The smaller give 224 amperes at 220–310 volts and 450 r.p.m., and the larger give 280 amperes at 460–500 volts and 350 r.p.m.

The *battery-room* contains 266 chloride cells, cast with 31 plates in lead boxes; their capacity is 750 ampere-hours for five hours, or 400 ampere-hours for one hour. The cables are Glover's single-wire "Diatrine" lead-covered type; the feeders are laid on the solid system and the distributors are steel-armoured and laid direct in the earth. A new feeder has been laid of Henley's paper-insulated lead-covered type, 1 square inch in section.

The street lighting is carried out by 36 Crompton arc lamps run four in series on the 230-volt mains. For private lighting the equivalent of 7,700 8-c.p. lamps was connected last January. The price charged is 5d. per unit for the first hour's use per day of the maximum demand, and afterwards 2½d. G. H. B.

2504. *Sunderland Electric Tramways.* (Electrician, 45. pp. 658–662, Aug. 24, 1900.)—The track is laid with 96-lb. girder-rails of high carbon steel, tensile strength 46 tons per square inch. The steel fishplates weigh

64 lbs., and the sole-plates 34 lbs. The rails are bedded on to 6 to 1 concrete, pasted up with 3 to 1 cement mortar. The joints are bonded with double 000 Columbia bonds, cross bonds being placed opposite to each pole, and the track bonds between each pole. Span wires ($\frac{7}{13}$) with rosettes have been used in Fawcett Street, and centre bracket and side poles elsewhere. Where bracket poles are used, the trolley wire of No. 0 S.W.G. is flexibly suspended by the fiddle-bow suspension. The poles are in three sections, and made to stand 1,000, 1,500, and 2,000 lb. strains, according to their position on the track. The brackets are of Mannesman tubes, and the details of the bracket-work, instead of being of cast iron, are of gun-metal painted. The entire equipment of the track is by Dick Kerr & Co.

Callender's cables are drawn into Sykes earthenware conduits placed in the clear way between the tracks. In addition to the return cables, two points, one near each terminus, are connected to a negative booster at the station through 0·3 and 0·25-inch cables. The negative boosters are made self-regulating by carrying the outgoing current through the series-windings of the boosters, thus making the boosted negative volts proportional to the load on the traction generators.

The cars, of which 26 are already built, are double-decked, mounted on Brill trucks, and carry 56 passengers. A useful feature is the illuminated destination boxes carried at each end. The trolley standard is in the centre of the car deck ; the greatest overhang of the swivel arm is about 7 feet, and the trolley wire is 22 feet clear of the ground.

Electric power is being provided from the Corporation Electric Supply Station, but the traction plant is distinct from the lighting plant. The chimney of the generating station is only 45 feet high, and on this account mechanical draught is required. It is found that by using fans, highly bituminous slack fuel can be burned without producing smoke. The traction generators are four in number, and consist of three-crank Belliss engines coupled to four pole dynamos giving 450 H.P. at 550 volts. E. K. S.

2505. *Metropolitan Railway, Paris.* **A. Dumas.** (Génie Civil, 37. pp. 97–219, July 21, 1900.)—This article, which is profusely illustrated on every page, and has five double-page plates of dimensioned details attached to it, comprises (i) an historical and general description of the proposed network of underground electric railways to be built by the city of Paris, and (ii) a detailed description of the portions already completed.

Six lines, with a total length of 65 kilometres, have been definitely arranged for. The city is to do all the substructure, estimated to cost 150 million francs, and a Concessionnaire is to build the superstructure (estimated at 50 million francs) and exploit the line for his own benefit for thirty-five years from completion, subject to a Government duty of 0·05 fr. on each second-class ticket and 0·10 fr. on each first-class ticket. Tickets are to be available from any one station on the Metropolitan to any other, and are to cost 0·15 fr. second class, and 0·25 fr. first class. Of the 65 kilometres definitely settled, 70 per cent. is underground, 16 per cent. is viaduct, and the rest cuttings. Steel Vignole rails will be used, 15 metres long and weighing 52 kg. per metre. A frequent service of short trains will be given, at a maximum speed of 36 kilometres per hour.

About 14 kilometres is actually completed, all of which is underground. Full dimensioned details of the tunnels are given. The rails are laid on creosoted sleepers to 1·44 metre gauge, with joints staggered and supported. Every 3 metres, longer sleepers are used to support the conducting rail

on insulators. The return circuit is through the track rails, whose joints are bonded with fine copper conductors of 0·15 metre diameter. Twenty-five stations have been built. The tunnels are electrically lighted throughout. Auxiliary tunnels have been driven through to the Seine to facilitate removal and delivery of material. The total cost of the substructure on the part completed is approximately 37 million francs, equivalent to 2,646·22 fr. per metre run. Shields on the Chagnaud system were used. The rolling stock is of the corridor type, with two side doors to each car, one for ingress and the other for egress only. The motors are carried in a cab forming part of the front car. Current is collected by a shoe suspended flexibly from the oil boxes of the motor carriages, each of which carries two Westinghouse motors. The motors are rated at 100 H.P. each, at 450 r.p.m., and drive by single-reduction spur-gearing, the diameters of the wheel and pinion being respectively 680 mm. and 265 mm. The motors are series-wound, and can for short periods give double their rated power. Series-parallel controllers are used. A speed of 36 km. per hour is allowed, but the actual speed does not exceed 30 km. per hour. At present there is a 10-minutes' service, which is to be increased to a 2 to 5-minutes' service from 5 a.m. to 1 a.m. In addition to an air-brake, all the cars have hand-brakes and emergency electric brakes. The Hall block-system of signalling is used, whereby the train itself blocks the lines by depressing a pedal which closes an electric circuit operating the signal.

A power station to supply the whole of the lines is nearly completed. In the meantime current is bought from various existing companies. The power station will have three batteries of six boilers each, one 1,500-kw. direct-coupled continuous-current set for 600 volts, and four 1,500 kw. three-phase direct-coupled sets for 5,000 volts and 25 periods. There will be one rotary transformer substation, where there will be a Tudor battery, as well as one at the power house itself, the batteries being intended to act as "fly-wheels." The boilers will be of the semi-tubular type; the engines are vertical compound Corliss condensing, each giving 2,600 I.H.P. at 70 r.p.m., with cylinder diameters 1·1 and 1·8 metres respectively, length of stroke 1·5 metres, and a flywheel 7·5 metres in diameter weighing 63,000 kg. The multipolar dynamos, by Creusot, have steel magnets and slotted bar-wound armatures. The alternators have rotating fields and stationary armatures. They are excited at 200 volts by either of two 50-kw. motor-generators, running at 525 r.p.m.

The stationary transformers are of 250-kw. size, grouped in two banks. The rotaries run at 250 r.p.m., and have a capacity of 750 kw. They will be arranged to take six-phase currents obtained by suitable grouping of the stationary transformers. E. H. C.-H.

2506. *Geneva Electric Tramways.* (Street Rly. Journ. 16. pp. 575–581, Aug., 1900.)—These tramways serve the city of about 100,000 people, and the canton with a population of 120,000, the area being 109 square miles. When the scheme is completed the expenditure will be about five million dollars for 100 miles of track. The gauge favoured in Switzerland is only 1 metre, which is also the gauge for the greater part of these tramways.

The company has 36 cars and is adding 90 new ones for the electrical equipment of which Westinghouse motors and controllers will be used. The network of feeders is laid in terra-cotta conduits, the number of ducts varying from 20 to 4. The cables are jointed as follows: They are first scarfed at an angle of 45°, and the base ends separated about $\frac{1}{32}$ inch and clamped in a bullet mould, into which nearly pure tin-solder is run. This at once solders

the ends of all the wires together and surrounds the whole core with an enlarged ferrule. The joint is then served, and a sleeve of lead pipe is slipped over, the ends of the sleeve being connected to the cable by means of a cast joint made of very fusible solder. An air pump is then applied to the pipe and the air exhausted until a vacuum is obtained, thus testing the integrity of the envelope with the soldered ends. If the joint is found to have good insulation, a hot, melted, resinous compound is run into a pipe leading into the joint, the opening into the joint having been previously stopped with a wax plug. The hot compound melts the plug and the vacuum forces in the compound, with the result that a joint is obtained of higher insulation than the normal cable itself.

The company is relieved of all necessity of generating its own current, as the city has developed the water power of the lake and river at its own expense. They have established a generating station at Chevres, about four miles down the Rhone. The original plant was by the Œrlikon Company, but Brown, Boveri & Company have recently supplied six 1,200-H.P. two-phase machines wound for 45 periods per second, and a potential of either 5,500 volts or 2,750 volts at will. They are of the umbrella vertical-shaft type with fixed armature and revolving field, having 46 poles carried by a cone-shaped magnet-wheel. The current delivered at Coulouvreniere for the street railway work is received at present by a 600-kw. machine, which delivers direct current to the system at 560 volts. The contract with the city is at the rate of 12 centimes per kw. hour for all current up to 1,800,000 kw. hours per annum, and above that at 9 centimes. The current is delivered through meter, and is available night and day. E. K. S.

2507. *Electric Traction on the Orleans Railway, Paris.* **J. A. Montpellier.** (Électricien, 19. pp. 344–346, June 2, 1900.)—The *Chemin de fer d'Orléans* has adopted electric traction for the underground extension of 4 km. which joins its Austerlitz station with a new station built on the site of the old Cour des Comptes. At the junction with the steam lines the various tracks are traversed by an electric transfer table 9 metres long, capable of carrying either the electric or the steam locomotives. There are eight electric steam locomotives, resembling the previous G.E. engines at Baltimore and Hoboken. They carry four motors on the four axles, with single-reduction gear, and are controlled by a series-parallel controller with magnetic blow-out. The locomotives normally take 500 kw. and weigh 40 tons, but can be weighted up to 46 tons to secure the extra adhesion necessary to draw a 250-ton train up a steep grade which occurs at one point on the line. Current is supplied through a third rail carried on paraffined blocks on the sleepers. The return current is through the track rails. The locomotives have three brakes in front and three behind. The central station, which supplies all the power and light, contains two 1,000-kw. three-phase generators, giving 5,500 volts at 25 periods per second, and has room for a third set. The engines are of the horizontal type. The primary current is used direct only in certain constant-speed auxiliary motors. The line is fed from two substations containing stationary transformers and rotary converters, each giving 250 kw. at 550 volts. These converters are connected in parallel with a battery arranged to supply the extra current required during the short period of acceleration. The lights are chiefly in series on a 500-volt continuous current circuit, fed by six 100-kw. rotary transformers, driven by three-phase synchronous motors run off the 5,500-volt circuit. The accumulators (Tudor) are in two batteries, each having a capacity of 1,100 ampere-hours on a one-hour discharge.

These batteries serve to equalise the load on the generating plant. The primary cables are armoured triple concentrics laid in the ground or in masonry ducts. E. H. C.-H.

2508. *Utilisation of Water-Power for the Electric Railway System of Minneapolis and St. Paul.* **E. P. Burch.** (Street Rly. Journ. 16. pp. 723–727; Discussion, p. 727, Sept., 1900. Paper read before the North-Western Railway Club, April 10.)—The source of power is the upper Mississippi River. A dam has been constructed below St. Anthony Rapids, giving an 18-feet fall. Turbines developing 10,000 H.P. drive directly two 1,000-H.P. low-pressure direct-current generators, which supply the nearer lines, and eight alternators generating at 3,500 volts, which supply substations at Minneapolis and St. Paul, the latter by a transmission line 9 miles long taking 2,000 H.P. at 12,000 volts. At the substations the alternating current is reduced in pressure and converted into direct current. The efficiency of the whole power system is very low. Of the 10,000 H.P. developed by the turbines the motors in ordinary work do not yield over 5,000 H.P. The cost of power is but 14 per cent. of the total cost of operation.

The paper is illustrated by a diagram showing the "flowage" of river, cross section of dam, map of dams, cross section through generating stations, drawing of turbines, and diagram showing method of splicing three-phase cables. J. T. R.

ELECTRIC TRACTION AND AUTOMOBILISM.

2509. *Calculation of Distributing Systems for Electric Tramways.* **H. M. Sayers.** (Inst. Elect. Engin., Journ. 29. pp. 692–729; Discussion, pp. 729–741, July, 1900.)—The conditions in lighting and traction systems are essentially different. In the former there is usually a short daily period of heavy load and a small load factor, and consequently economy in capital expenditure is of relatively great importance. In a traction system the special conditions are (1) high-load factor, a large output being generally required for fifteen to eighteen hours a day; (2) large permissible variation in pressure, 10 per cent. causing no inconvenience; (3) unsymmetrical arrangement of the two conductors. Practically all the drop occurs on the outgoing insulated side of the system. The author gives a method of working out the most economical current density, starting with Kelvin's law. He concludes that the limiting distance due to loss of pressure in feeders designed on economical principles is two to three miles from the generating station, and this limit is unaffected by traffic density, but varies directly as the cost of energy. For distribution over larger distances three systems are in use in the United Kingdom:—(i) The multiplication of continuous-current low-tension stations, (ii) the use of battery substations charged from a single generating station, (iii) the use of one high-pressure polyphase station distributing to substations whence low-tension continuous current is supplied. The second system is little used, and its application seems limited to cases of infrequent service on distant lines, such as arranged by J. Hopkinson at Leeds.

Assuming a permissible drop of 10 per cent., or 50 volts, on the trolley wire, and a uniform distribution of cars, the average drop over the whole system will be 5 per cent. in the trolley line, to which must be added the loss in track feeders, probably 2½ per cent. As the "interest" item of distributing costs equals in value the "loss of power" item, it follows that the distribution costs in such a continuous-current system will equal 15 per cent. of the value

of the power delivered to the car, and 115 units must be generated for every 100 units required at the cars. In a multiphase transforming system the overall efficiency cannot be taken at more than about 80 per cent., which means 125 units generated for every 100 units used at the cars. The author concludes that for equal costs under these two systems the cost of generation at the single high-tension station must be less than 88½ per cent. of the cost at the low-tension stations by the cost per unit of interest, attention, and stores due to the transformers.

The principal part of the paper is unsuitable for abstracting, being the working out in detail of the costs of distribution in a particular example, with single and multiple continuous-current stations, or with a multiphase station. Appendices give detailed calculations for "boosted" feeders and track feeders.

Discussion.—**E. Thomas** pointed out that the most economical distribution does not necessarily correspond to the most economical system considered as a whole, and **J. Swinburne** urged reconsideration of the three-wire system for tramways, and suggested the use of a booster on the middle return wire. E. H. C.-H.

2510. *Polyphase Electric Traction.* **C. A. Carus-Wilson.** (Inst. Mech. Engin., Proc. 3. pp. 435–458; Discussion, pp. 459–462, June, 1900.)—An important paper describing the equipment of the Burgdorf-Thun three-phase railway, and giving results of tests made by the author to find out the performance in acceleration, coasting, &c. Two of the three appendices also give interesting notes on the action of a polyphase motor, with special reference to its behaviour as a railway motor; also particulars of the windings of the Burgdorf-Thun motors.

With steam traction it is necessary to make up trains of considerable length to meet expenses; hence where the traffic is small the train interval is large. With electric traction single independent cars can be run economically at frequent intervals. This breaking up of the traffic into small units has also a marked influence on the punctuality of the train service, as it enables the staff of the various stations to handle the traffic and luggage with greater facility. It is especially an advantage when temporary increases of traffic have to be handled. The punctuality is also affected by the question of gradients, and whilst the continuous-current motor shows a large reduction in speed at heavy loads, the polyphase motor, on the other hand, runs at a practically uniform speed, entirely independent of load or grades. Experiments were made by the author in which the records showed no appreciable variation of speed when the load on a motor car on the Burgdorf-Thun line was increased from 32 to 68 tons, and only 2 per cent. fall when a 50-ton train ran from a level up a grade of 1 in 40. With the polyphase system a temporary increase in the traffic can be carried by adding trailers to the motor cars up to the full power of the motors with no complication of controllers or increase in the working staff, and without any appreciable influence on the speed. Particulars are given of the Burgdorf-Thun railway, for which see also Abstract No. 765, 1900.

The author goes into the question of acceleration very thoroughly, and makes an interesting comparison between this line and the South Side Elevated Railway (continuous current) at Chicago, which is very similar in weight, &c., and is equipped on the Sprague multiple unit system. It is shown that the continuous-current equipment can get up a speed of 24 miles per hour with 39·5 watt-hours per ton in 37 seconds, as compared with 45·1 watt-hours in 30 seconds with the three-phase equipment. Thus the con-

tinuous-current motors use 87 per cent. of the energy required by the three-phase motors, while the three-phase motors get up full speed in 81 per cent. of the time taken by the continuous-current motors. The reduction of energy in the continuous-current motor is due to the use of the series parallel controller, but the author further deduces from his experiments, and the particulars given in F. J. Sprague's paper, that the maximum power input as obtained in actual practice with the three-phase motor is only about 70 per cent. of that with the continuous-current motor.

The tests go to show that polyphase motors are admirably adapted to getting up speed, and that the acceleration can be maintained uniform up to full speed. The comparison of results with those obtained on one of the most complete continuous-current equipments shows that there is very little difference between the two in economy of starting. The continuous-current motors have a slight advantage in the amount of energy expended, while they occupy a longer time in reaching high speeds, and require larger maximum power inputs than the polyphase motors.

Discussion.—**S. F. Walker** was of opinion that the continuous-current motor would stand overloading right up to the point where either its insulation burnt up or some part of its arrangement for transmitting power mechanically to the driving axles broke down. The polyphase motor, on the other hand, under present structural conditions would not go beyond a certain overload. In his reply **C. A. Carus-Wilson** stated that the breakdown load of a polyphase motor was 1½ times the rated maximum safe working load, a limit which would fairly cover any temporary overload in practice. Further, the polyphase system admitted of the whole installation, from generator to motor, being worked without any kind of safety or automatic cut-out, even safety fuses being dispensed with if suitable generators were used. Under these circumstances an interruption in the train service due to overload was far less likely to occur than with the continuous-current system, where safety fuses and automatic cut-outs were essential. E. K. S.

2511. *Electric Traction.* (Amer. Inst. Elect. Engin., Trans. 17. pp. 311–335, May, 1900.)—**F. Sprague,** in opening this discussion on Boynton's paper [see Abstract No. 1595 (1900)], remarked that when the electrical operation of a trunk-line system was under consideration, the freight service must not be forgotten. Freight service differs considerably from passenger service, and can be most economically transported in long trains drawn by a single locomotive with a small crew of men. For electric traction to be a success, there must be nowhere on the line a localisation of large units at long intervals; the more units and the closer together they are the better. They must be evenly distributed over the system. One of the great advantages of electricity as a motive power is that it can be adapted so as to use the whole weight of the train for traction by means of the "multiple unit system." This system also has the advantage that the power of a train is directly proportional to its capacity, no matter how long it may be. With electric locomotives the limitations of the system are very much the same as with steam.

The two most important things which have been brought forward and practically developed during the last two or three years are storage batteries (as a means of equalising the load) and the multiple unit system. The storage battery is a necessity in any large development of the application of electricity to traction.

The cost of power stations is more like $200 per kilowatt output than the $80–90 spoken of by Boynton.

Ice can generally be kept from the third rail by running a fast car over the lines on the approach of sleet, and in the multiple unit system the front shoes cleared away the ice whilst the back ones took the supply of current, and there was very little sparking.

Boynton, in replying, said that he was not quite able to associate the multiple unit system with all conditions of steam railroading, but that doubtless for suburban conditions of traffic in cities it was applicable. He was of the opinion that electric traction would begin under steam railroad conditions, perhaps afterwards developing into a multiple unit system. The use of storage batteries in connection with electric traction is undoubtedly on the increase. With reference to ice on the third rail, he had experienced a good deal of trouble with a certain kind of ice which stuck like a coat of varnish. It would not chip off, but had to be planed off by specially arranged steel tool planers. P. D.

2512. *American Tramway Practice.* **A. E. le Rossignol.** (Electrician, 45. pp. 711–712; Discussion, p. 712, Aug. 31, 1900. Paper read before the Municipal Electrical Association at Leeds, June 23.)—The present practice in tramway construction leans towards the erection of a large central power station with high-pressure distribution to substations. Coal-handling and storing machinery is always used, and thus the fuel costs are kept remarkably low. The companies are reticent as to actual figures. The generating sets are large, of the open slow-moving type, with mechanical oil supply. The question of providing adequate boiler power on a reasonable amount of floor space to correspond with the engine floor space has been met by the adoption of two or more boiler floors one above the other, surmounted by huge coal bunkers at the top—a method which exemplifies the trust placed by American engineers in steel-framed buildings.

Underground conduits seem to work very successfully, but have been introduced only in New York and Washington. Two conductors are always used, and means provided for changing these conductors on to either positive or negative bars, so as to enable traffic to be kept running even with one conductor grounded in any or every section.

In no case, so far as the author is aware, are return current boosters used, so that even with good bonding the maximum fall is great. There is no limit fixed by law; the only limit the companies recognise is an economic one. Electric and cast welding are employed, the latter being most favoured; no supplementary bonds are used, as would be required in this country to keep within the Board of Trade limit of 7 volts.

Discussion.—**C. H. Wordingham** was of opinion that all drawing-in systems will have to be given up, as they are fatal to the cable. **S. Z. de Ferranti** said that he noticed that all the important switches (in the Metropolitan Company's Station, New York) were placed two in series. He mentioned that S. H. Short was of opinion that having several stations was cheaper in first cost and running than one large power station as in New York. E. K. S.

2513. *Rail-Joint and Bond Resistances.* **W. E. Harrington.** (Frank. Inst., Journ. 149. pp. 401–419, June, 1900.)—A Weston millivoltmeter was connected by contacts of Edison-Brown alloy across 24 inches of various rails, with and without various joints and bonds. Tests were made by placing the rail in series with an ammeter and water rheostat, and taking readings of the drop in millivolts at each reading of current through the rail. The rail

tested was a 9-inch girder rail ("P. S. Co.'s Section No. 200"), and the average resistances between the voltmeter contacts at 24 inches on the rails were found to be:—

Test.	Ohm.	Percentage Difference from Resistance of Solid Rail.
Solid rail	0·000020	...
Plain cast weld	0·000026	+ 30
Cast weld with copper contacts	0·000040	+ 100
Plain cast weld with 2–4/0 Bryan bond	0·000018	— 10
Plain cast weld with $\frac{1}{2} \times \frac{7}{8}$ Edison-Brown alloy plug	0·000021	+ 5
Plain cast weld with 30 in. × 4 in. × $\frac{1}{8}$ in. sheet copper outside	0·000016	— 20

From other tests with various rails and bonds it appears that the conductivity of a joint is quite comparable with that of the rail itself, and, if double bonding is used, the resistances can be made less than the rail resistance, particularly with bonds other than those expanded into holes in the foot or web of the rail. The author sums up as follows:—(*a*) The cast weld joint alone has a resistance 30 per cent. greater than that of the solid rail. (*b*) The use of sheet copper, as furnished by the Ajax Company, makes the combined resistance 20 per cent. less than that of the solid rail. (*c*) Where the cast weld joint is not employed, and the usual fishplate form of construction is adopted, the flat sheet surface-contact form of bond, known as the "Ajax," makes the most efficient type of bond, both electrically and mechanically, making the resistance only slightly more than that of the rail, whereas the other types make the resistance from three to four times more. E. H. C.-H.

2514. *Fall of Potential along Tramway Rails.* **E. Parry.** (Electrician, 45. pp. 595–598, Aug. 10, 1900.)—The author first considers the problem of the distribution of potential along a bare conductor laid in the earth, the ends of which are maintained at potentials + V and — V respectively. The value of the potential v at intermediate points is found by solving the equation—

$$\frac{d^2v}{dx^2} = \frac{Lh}{Ak}v, \tag{1}$$

where v is subject to the condition that—

$v = + V$ when $x = 0$,

and— $v = - V$ when $x = X$.

Also— A = the cross-sectional area of the rail,

L = the surface area of the rail per unit length, in contact with the earth,

k = the conductivity of the material of the rail,

h = the external conductivity between the rail and earth.

The equation is the same as that given by Fourier to find the temperature at any point of a heat conductor exposed to the air whose ends are maintained at constant temperatures. From (1) v is found, and hence the current $\left(-kA\frac{dv}{dx}\right)$ is also determined. The author found that for a modern type of

girder rail, $\frac{L}{A}$ was equal to 3·15. Following H. F. Parshall, he takes k to be $\frac{10^6}{7 \cdot 35}$, and by experiments over lengths of seven miles and four miles of double track, he found h to be $\frac{1}{737,000}$. From these data he finds that—

$$\sqrt{\frac{Lh}{Ak}} = \frac{1}{180,000}$$

Curves are drawn illustrating the solution of (1), and showing also the ratio of the maximum and minimum currents in the conductor for various lengths of track. The maximum current density in the rails is assumed to be 2·5 in all cases. He shows, for example, that when the track is eight miles long the stray current is 54 per cent., and the total potential difference is 7·8 volts. A practical numerical example is also given, showing how to take into account the resistance of the joints along the rails. A. R.

2515. *Joint Construction.* **H. Koestler.** (Street Rly. Journ. 16. pp. 399–400, May, 1900. From a paper read before the Fachgruppe der Bau- und Eisenbahn-Ingenieure, of Vienna, Jan. 18.)—On the Electric Underground Railway at Vienna the "Stossfangschiene," or "Barschall Joint," has been in use for from 1½ to 2¾ years. This joint has in place of the outside angle plate, a rolled piece of rail 550 mm. in length, made of the same material as the rail itself, and shaped in such a way that for a distance of 180 mm. its running surface is on the same level as the running surface of the rail. The ends are chamfered off so that in the course of time surfaces are produced which will effect a smooth transition of the wheel from section to section. Between the outside and surface rails is an intermediate eight-shaped piece. The running is smooth and noiseless, the wear on the joints has not been noticeable, and only 1 per cent. of the joints have been replaced on account of failure of material, which occurred a few days after the road was opened. The wear at the joints has been no greater than at any other portion of the rail, and there has been no flattening at the joint proper, which might have been produced by a slight drop of the wheels at that point. Upon careful examination of the intermediate rail between the two others, it was found that it did not press into the head or base at any point, that it was tight along its whole length, and that there had been no friction, as is the case with most fishplates. There have been no breaks recorded of the inner rail on a total of 12,000 joints, and no perceptible wear of this piece. In fact, it has been found that the rail wears and works as a unit. It has further been found that it is not necessary to tighten the joints as frequently as is the case with ordinary fishplate joints, and this reduces the cost of maintenance considerably. In Vienna it is concluded that the extra first cost of this joint will be made up by the increased life of the rail. E. H. C.-H.

2516. *Electrolysis by Earth Returns.* **A. B. Herrick.** (Street Rly. Journ. 16. pp. 396–399, May, 1900. Paper read before the New York Electrical Society, April 20, 1900.)—In a 9-inch girder rail the surface of contact is about 1,300 square feet per thousand feet of rail. Modern paving methods, with cement underneath the rail, increase the resistance to current flowing away from the rail, and asphalte or waterproof pavements over the roadway protect the underlying soil from surface water, and in this way increase the natural resistance of the earth's circuit. When the current leaves a metallic surface which is buried in the earth, it does not carry with it the decomposed

metals, as in a plating bath, and deposit them on the kathode. On the contrary, the products lie adjacent to the surface acted upon, and when the metal is iron they generally form oxides. These oxides increase the resistance to the flow of current and, consequently, the resistance also of the return circuits by way of the earth. This effect is actual as well as theoretical, and the gradual falling off of the current returned by the water-pipe system can be noticed in roads where the ground returns are properly located and bonding is maintained. With a lead service pipe connected to an iron pipe there are two metals which, when buried in the earth, form an earth battery which will cause a current to flow between them when their ends are connected together, as is the case when a cast-iron pipe has a lead service pipe tapped into it. This matter was seriously considered when iron pipes were first used for underground systems, and the method of connecting finally adopted was to use a brass nipple between the iron and lead pipe; a brass and iron connection corrodes and forms a high-resistance contact, thus breaking up these local earth currents. When the railway current seeks a return to the rails these lead service pipes offer the nearest path through the earth to the rails, as they usually pass under the rails to cross the street to a water connection on the opposite side. On carefully digging away the earth between the lead service pipes and the rail where it has passed a current to the rails, it is found that threads of lead oxide reach from the lead pipe to the rails through the earth; in some cases the lead oxide shows great migratory powers. Actually when the real destruction is measured with cast-iron plates buried in the earth and kept moist, the amount of metal destroyed is only 3·46 per cent. for the first 100 hours, of the theoretical rate for iron in its proper salt solution; this rate falls rapidly after 100 hours. The resistance of clay with 6 per cent. moisture, is on the average about 2·7 billion times, and of sand with 8½ per cent. moisture, about 1·3 billion times that of copper; in tidal districts where the earth is saturated with salt water, the earth resistance is as low as 1 billion times that of copper.

The methods of testing employed to discover the flow and points of departure of subterranean currents are as follow. First, to find where the currents enter the water-pipe system. The water-pipe system is cleared of all known connections to the rails or negative bus-bar, and between the negative and the water main near the station, a recording ammeter is inserted, and a second recording ammeter in the ground return circuit. A car is provided for use as a test-car with a water-barrel rheostat, made of two plates of ⅛-inch iron about 14 in. by 24 in., and filled with water, using bicarbonate of soda to reduce the resistance of the water; when the water is heated by the current to about 60° F. it will carry about 140 to 200 amperes. This rheostat is connected between the trolley and ground with a switch in circuit. The car is run after traffic has been stopped; the assistant is provided with a map of the route on which are marked quarter-mile intervals. At the end of each interval the car is stopped and the circuit closed. By arranging beforehand the number of times he must pull the switch, or the length of time he must leave the switch open at each stop, a system of breaks will be made by the recording ammeter, which will give on the chart the position of the test car on the system. The next step is to find the current that has passed into the water-pipe system through the earth resistance between the rails and the piping system. Two adjacent water-plugs are connected together, first by a voltmeter line, and the voltage V_1 is read. Then these two plugs are connected together through a low reading ammeter, and readings are taken of the amperes A, flowing at the voltage V_2. The true

current X, flowing in the pipe is given by the proportion, $V_1 - V_2 : V_1 :: A : X$. The remedy for electrolytic troubles is to form a system of electrical drainage of the water-pipes, taking care, however, not to thereby increase the flow of current into the pipes. To secure this, a return feeder of suitable resistance must be connected to the pipes at a point where there is no difference of potential between the rails and the pipes. The water company can almost entirely prevent all trouble by using coated iron instead of lead service pipes, and by using high-resistance sulphur and iron filings for joints instead of lead. E. H. C.-H.

2517. *Electrolysis by Earth Returns in Brooklyn.* **S. Sheldon.** (Amer. Inst. Elect. Engin., Trans. 17. pp. 337–342, May, 1900.)—During busy hours there are 1,100 cars on the tracks in the borough of Brooklyn, supplied with a total of 47,000 amperes from seven power stations. There are five paths for the return current: (i) The rails; (ii) the East River (this path takes a large proportion of the return current at certain hours when most of the cars are bunched at the "down-town" end); (iii) return feeders; (iv) the Elevated Railway structure; (v) water- and gas-pipes; telephone cables and Edison "tubes." The difference of potential between the rails and the gas- or water-pipes sometimes reaches 25 volts. Between the two ends of Brooklyn Bridge there has been 20 volts, and 40 volts is not unknown between a power-house and the most distant point supplied by it. The water mains are cast, either of hard and tough "Scotch" iron or softer American iron. In no case has electrolytic corrosion of water mains been discovered, but many wrought-iron service pipes with malleable-iron or brass fittings have been destroyed. The Gas Company claim that since the advent of electric traction, the leakage has increased abnormally. It now amounts to 13 per cent. of their output. The lead covering of the telephone cables has been much pitted. The true cause of the immunity of cast-iron is that, in the casting of pipes in sand moulds, the hot iron unites with a layer of the sand to form a silicious compound, probably silicate of iron, which forms a thin coating over the surface of the completed pipe. This coating is extremely thin, and is a non-conductor of electricity. It is not continuous, but contains perforations in many places. If, however, a current be made to pass for a few moments under a moderately high impressed E.M.F. the rough sand-pocked surface becomes conducting throughout. The protecting film or skin seems to act like the non-conducting film thrown down in an aluminium cell. The resistance of the soil is important in preventing corrosion, and may be determined from the formula $X = R\,[(E \pm E')/\theta - 1]$, where R is the resistance of a low-reading voltmeter, and E', E, and θ are respectively its readings (i) across the two points between which the soil resistance is required (*e.g.*, between a hydrant and the rails); (ii) across the terminals of the battery only; and (iii) with the battery and voltmeter connected in series across the points. From many experiments, it appears that the soil resistances between rails and water hydrants lie between 10 and 35 ohms. The character of the pavements appears to have no influence on the resistance of the soil underneath [this is contrary to the preceding Abstract.] E. H. C.-H.

2518. *Electrolysis by Earth Returns.* **D. H. Maury.** (Eng. News, 44. pp. 38–42, July 19, 1900. Slightly condensed from a paper read before the American Waterworks Association, May, 1900.)—Since 1893 116 electrolytic breaks of lead service pipes have been recorded by the Peoria Waterworks Company. Investigations proved electrolysis by finding the lead redeposited in a thin

coating on the surrounding soil in the direction of the electric railway tracks. Similar deposition of metal was found in the cases of wrought-iron gas services and cast-iron gas and water mains, the soil around the joints of the latter being often stained with oxide of iron, while immediately in front of the ring of lead in the joint was a thick metallic deposit of lead. In 1894 one of this company's steel standpipes burst, more than a mile from the power house, and killed two persons. The whole inner surface of the vertical shell was covered with thin blisters, resembling those found on old cast-iron mains. These blisters were composed of oxide of iron, and underneath them was the original coating of black paint almost unbroken, but on scraping off the paint, pits would be disclosed of considerably smaller area than the blisters, and having a perfectly clean, bright metal surface. Cast-iron water-pipes are coated inside and out with a preservative coal-tar preparation, and in a spigot joint the spigot end only touches the bell end at the extreme end of the spigot pipe, as the latter is kept central in the bell by a ring of yarn before the lead is poured in and caulked. The author finds by tests that, contrary to the usual belief, the tar coating is not burnt or injured in any way by the heat of the molten lead. He tested the resistance of many joints, and found it to vary up to several thousand times that of the same length of continuous pipe; the resistance of the joint was unaffected by caulking the lead tightly or very loosely. The average resistance of a joint was 227 times the resistance of 4 inches of plain pipe. The resistances were found (in eleven months) to increase with age. Even if each joint only shunts 1 ampere of the current in the pipes the total effect of this 1 ampere is cumulative and serious, whereas 1 ampere leaving the pipes for the rails only makes one pit. Reducing the actual and relative conductivity of the pipe lines compared with the rail returns only results in more widely scattered but less rapid destruction. The only satisfactory preventive of electrolysis of underground metallic structures is to keep the return currents out of the ground. In Cincinnati 220 miles of track are equipped with the double trolley system, and after ten years' experience the managers declare that the cost of operation and maintenance is less than it would be with single trolley. An incidental advantage of double trolley is that both rails may be sanded. By recent Acts of Congress all new tramways or extensions in the District of Columbia are required to be on the overhead double trolley system.

E. H. C.-H.

2519. *Rolling Stock of the City and Waterloo Railway.* **D. T. Heap.** (Tram. Rly. World, 9. pp. 298–299, July, 1900.)—Some single-car stock has recently been placed on the Waterloo and City Railway, in order to give a more frequent service during light hours, while also reducing wear and tear, with the following favourable results:—(*a*) The consumption of energy per hour for the single-car service (exclusive of the power supplied for the auxiliary circuits) is less than when the 10-minutes' service was being maintained, although the average speed for the single journey has been increased to 18 miles per hour and a 5-minutes' service given instead of 10 minutes. (*b*) The acceleration of the car is very good, being at the rate of 1·74 feet per second on the "Up" road on leaving Waterloo. (*c*) The rolling load per hour over the running road is considerably reduced. (*d*) The maintenance expenses of the single cars will be less than is the case with the 4-car trains, the equipments being of the 2-motor geared type instead of the 4-motor direct type; and (*e*) these advantages have been obtained, as well as an increased passenger train mileage, with a reduction in the operating expenses. E. H. C.-H

2520. *Profits on Tramway Undertakings.* **C. H. Gadsby.** (Elect. Rev. 47. pp. 75–77, July 13, 1900. Paper read before the Tramways and Light Railways Association, Islington, June 29, 1900.)—Tables are given showing in detail the operating expenses on English horse, steam, and electric tramways, also on American electric trams. The average operating expenses per car mile for these different systems are respectively 9·5d., 10·7d., 6·9d., and 7·2d. American and English electric expenses agree closely in the details. In America it is common practice to get 100 to 120 miles per day out of a car; in England, 35 to 40 miles only is not uncommon. The author concludes that (i) it is generally possible by increased services to increase the gross receipts; (ii) the operating expenses do not increase at the same rate as the mileage, and generally at a less rate than the receipts; (iii) judicious increase in services generally results in larger net profits; (iv) electric traction is the readiest means of increasing the receipts, while at the same time reducing working expenses.

The following table shows the number and sizes of generators recommended for running various numbers of cars:—

No. of cars	5	10	15	20	30	40	60	80	100
No. of sets of generating plant, including reserve	2	2	2	2	2	3	3	3	3
Power of each set in kw.	16	125	175	225	300	200	250	300	350

E. H. C.-H.

2521. *Merriman's Rising Contact Stud.* (Elect. Engin. 25. p. 917, June 29, 1900.)—A new form of this is illustrated, and is claimed to overcome the drawbacks of the original form [see Abstract No. 772 (1900)] in which (i) grit was liable to get under the treadle and prevent its operation, and (ii) an ordinary waggon-wheel might accidentally operate the treadle. In the new form the treadle has to be wedged out of the rail groove by the car-wheel, this movement of the treadle raising the contact stud above the ground-level, while at the same time bringing it into contact with the feeder. Attached to the end of the lever arm that raises the stud is a heavy weight, which ensures the stud being pulled down again after the passage of the car. E. H. C.-H.

2522. *Electric Automobiles in Boston.* (Elect. World and Engineer, 35. pp. 895–897, June 16, 1900.)—A company formed in May, 1899, now handles 150 electric vehicles. The cabs are stored and cleaned on a first floor approached by an 8 per cent. grade, and the batteries charged on the ground floor. A lift is provided for exhausted vehicles, which are unable to climb to the first floor. There will finally be eight loading stands, with mechanism for pulling the batteries out and putting in fresh ones. The empty batteries are put into elevators and taken to the charging floor. Power is taken from the three-wire system of the Supply Company and the charging current is regulated by a rheostat for each battery, no "multiple bus-bar" arrangement being used. Current is kept approximately constant during charge. For moving about the building a special wire is provided running over a pulley at the centre of the roof, and counterweighted. A special portable pump is used for drawing up acid from the cells into a hydrometer. A ring of substations for charging is being formed on a four-mile radius from the central station. E. H. C.-H.

ELECTRIC LAMPS AND LIGHTING.

2523. *Electric Train-lighting.* **G. D. Shepardson.** (Elect. World and Engineer, 36. pp. 5–8, July 7, 1900.)—The Chicago, Burlington, and Quincy

Railroad has provided electric lighting in its "Burlington Express," designed to "eclipse every competitor." There are 265 lights on the train, and storage batteries are employed, charged at the ends of the line. Each car carries 48 cells of the Pullman and American types, rated at 160 ampere hours, and each weighing 56 lbs. The plates (4 positives and 5 negatives) very nearly fill their hard-rubber boxes, and this is found to prevent the acid "slopping" over when the train starts or stops rapidly. With the heavy vestibule cars now common the weight of the batteries averages less than 2 per cent. of the car it serves. After three years' experience of the system the master mechanic in charge is convinced that electricity is much the best system, and that a battery is more economical than an engine and dynamo. E. H. C.-H.

2524. *Series Enclosed Alternating Arc Lighting for Streets.* **W. L. Robb.** (Elect. Rev. N.Y., 36. pp. 532–533, May 23, and p. 563, May 30, 1900. Extracts from a paper read at the Chicago Convention of the National Electric Light Association, May, 1900.)—The author deals in a general manner with the systems which are at present used in connection with street-lighting from an alternate-current works supply, discussing the relative advantages of each.

The street-lighting of Hartford, Ct., is described. In all there are 804 street lights : 700 are operated from constant-current transformers in series on alternate-current mains, the rest from a constant pressure three-wire system. Eight 100-light, constant-current transformers are used, which run without attendance. They are constructed with a straight central core carrying at the ends two fixed primary coils, and between these, over the central part of the core, two movable secondaries. The motion of the coils is vertical, and they are slung by chains, to which is attached, outside the oil-filled cast-iron transformer case, a lever supported on a knife-edge and carrying a counter-balancing weight.

The lamps are trimmed once in six days, at an annual cost per lamp of \$2 ; when open-type lamps were used, the trimming cost \$8. The cost of carbons per lamp per annum is \$1·50, that with open-type having been \$5·84. The cost of inspection is unchanged. The cost of replacing inner globes is 30 cents per lamp per annum, but the breakage of outer globes is considerably less than was the case when open-type lamps were used. The total yearly saving by the substitution of enclosed-arc for open-arc lamps in carbons, trimmings, and repairs amounts to over \$10 per lamp. In addition, the number of hours lamps have been out has been reduced about 50 per cent. A good deal of the success of enclosed lamps depends upon the cleaning of the cylinders, which ought to be done with brush and hot water every time the lamps are trimmed. By running the series transformers at about 90 per cent. of the full load the efficiency and power-factor of the system are satisfactory. The power-factor would have been considerably increased if shunt-wound lamps had been used, but differential lamps were adopted owing to their more satisfactory working.

The author afterwards compares the system of Hartford with other methods of arc-lighting from alternate-current supply, and from the results gives the opinion that, in the near future, generally speaking, when the alternate-current supply has a frequency of 60 per second, the series arc-lighting will be by series alternate-current enclosed-arc lamps ; that when the frequency of the supply current is 25 per second, the series arc-lighting will be by series direct-current enclosed-arc lamps supplied with current from rectifiers. E. D. P.

TELEGRAPHY AND TELEPHONY.

2525. *Interior Telephone Systems.* **W. S. Henry.** (Amer. Electn. 12. pp. 401–404, Aug., and p. 443, Sept., 1900.)—The author describes "intercommunicating" systems having three or more telephones connected to the same system of wiring in such a manner that one station can call up any other without a central switchboard. An ordinary method, but not a good one, is to have a common return wire for all and a separate wire for each, the latter being connected in each office to a switch. The handle of the latter is movable over contacts numbered according to the numbers of all the stations. Then in each station No. 1 contact is joined to No. 1 line, No. 2 contact to No. 2 line, and so on. The switch handle of the station calling is moved to the number required, and when a ring is given the other stations are undisturbed. When all the stations are quiet the handles of the switches must rest upon the contact bearing the numbers respectively of the stations themselves, otherwise the system will be crippled. To avoid liability to this accident a recent device prevents the hanging of the receiver upon its hook when the intercommunicating switch lever is not in its normal position. The switch has an attachment that blocks the entrance to the receiver hook whenever the switch lever is off the "home" position, so that the latter must be returned to its appropriate stud before the receiver can be hung up. This device can be applied to almost any telephone. Another method, devised to obviate the inconvenience caused by failure to return the intercommunicating switch to its proper rest contact, consists in connecting the terminal of the telephone other than that joined to the common return to the arm of the switch as well as to its own line wire, so that if any station should accidentally leave the switch to a working contact other than his own, he does not interrupt communication between the others, and, being in derivation, will receive any ring that passes, and can be dismissed if he answers and is not required.

To adapt such a method for use with a common calling battery and vibrating bells in place of magneto-generators and polarised bells one more wire is required, joined to one pole of the battery (which can be placed in any situation) and to the "make" contact of the bell push in each station, the other pole of the battery being joined to the common return wire of all stations. The bell of the calling station does not ring, but only that of the station called. It is necessary to arrange the key to cut out the home bell owing to the difficulty in getting two vibrating bells to work well in series on one circuit. Selection switches are used as in the previous systems described, and should they be carelessly left off the "home" buttons the bells are left in parallel, and a calling current is subdivided and becomes possibly unable to ring the station required. E. O. W.

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[*Names not followed by Titles are not Authors, but only names mentioned in Abstracts. The numbers refer to Abstracts, those in Italics referring to References. An asterisk indicates remarks in a discussion.*]

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SUBJECT INDEX.

To facilitate reference to any desired subject, the Index is divided into the following sections arranged alphabetically. If any of these are absent this may be taken as an indication that no Abstracts dealing with those particular subjects have been included in this volume.
The numbers refer to Abstracts, those in italics referring to References.

In General Physics:—Apparatus and Instruments (physical, excluding electrical, descriptive); Astronomy; Elasticity; Gravity; Measurements; Meteorology, &c.; Miscellaneous; Surface Tension; Theories.
In Light:—Absorption (light and heat); Dispersion; Interference; Measurements; Miscellaneous; Phosphorescence and Fluorescence; Photography; Photometry; Polarisation; Rays; Reflection; Refraction; Spectra; Vision; Zeeman Effect and Radiation in a Magnetic Field.
In Heat:—Absorption (light and heat); Conductivity (thermal); Critical Points and Constants; Dilatation; Freezing-, Melting-, and Boiling-Points; Gases and Vapours; Measurements; Miscellaneous; Specific Heat and Latent Heat; Temperature; Temperatures (high and low); Thermodynamics; Vapour Pressure.
In Sound:—All Abstracts referring to this subject have been indexed under *Sound*.
In Electricity and Magnetism:—Absorption; Alternate Current Research; Apparatus and Instruments (descriptive); Capacity (electrostatic); Conductivity and Resistivity; Dielectrics; Discharge in Gases and in Vacuo; Induction; Induction (self and mutual); Measurements; Medical Electricity; Miscellaneous; Oscillations and Waves; Polarisation (electric waves); Polarisation (electrolytic); Resonance; Static Electricity; Terrestrial Magnetism and Electricity; Thermo-Electricity and Thermo-Magnetism.
In Chemical Physics:—Absorption; Batteries (primary); Batteries (secondary); Chemical Equilibrium; Dissociation and Ionisation; Electric Furnace Processes; Electrolysis (commercial); Electrolysis (except commercial); Electrolytic Analysis; Miscellaneous; Osmosis; Solution and Solubility; Vats and Cells (electrolytic).
In Steam Plant, Gas and Oil Engines:—Accessories (steam plant); Automobiles; Boilers; Condensers; Economisers and Feed Water Heaters; Gas Engines, Gas Producers, &c.; Miscellaneous; Oil Engines; Steam Engines.
In General Electrical Engineering:—Accessories and Appliances (electrical, excluding traction); Apparatus and Instruments (descriptive); Batteries (primary); Batteries (secondary); Equipment of Factories and Machine Tools; Insulation and Insulators; Miscellaneous.
In Generators, Motors, and Transformers:—Alternators; Dynamos; Miscellaneous; Motors; Rectifiers; Transformers and Rotary Converters.
In Power Transmission, Traction, and Lighting:—Accessories and Appliances (traction); Automobiles; Cables, Conductors and Wiring; Costs; Electricity Works (descriptive); Lamps (arc) and Arc Lighting; Lamps (incandescent); Miscellaneous; Power Transmission and Distribution; Traction (electric, by accumulators); Traction (excluding accumulator traction and descriptions of power stations); Traction (mechanical).
In Telegraphy and Telephony:—Telegraphy (excluding wireless telegraphy); Telegraphy (wireless); Telephony.

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UNWIN BROTHERS, THE GRESHAM PRESS, WOKING AND LONDON

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